

PORTABLE COMPUTERS: MORE POWER PER POUND

HIGH TECHNOLOGY

APRIL 1987


THE MAGAZINE FOR TECHNOLOGY MANAGEMENT

PRICE \$3.00

ARTIFICIAL INTELLIGENCE GOES TO WORK

**REVAMPING THE
CHEMICAL BUSINESS**

**TV SCREENS:
BIGGER GETS BETTER**



**The real intelligence
behind automated
credit authorization
at American Express:
Laurel Miller and
Bob Flast.**

0 02788

04



884266

Knowledge

TI's third Artificial Intelligence Satellite Sym



"AI will be a significant force in the worldwide competition for productivity leadership...and a key enabler for the new billion-dollar markets of the future. TI can help you lead the way."

— Dr. George Heilmeyer, Senior Vice President and Chief Technical Officer, Texas Instruments

Artificial Intelligence is moving quickly into the mainstream of business for many of the world's leading corporations. And as its momentum builds — from the factory floor to the trading floor — it becomes crucial to manage AI technology as the strategic resource it is.

Technologies:

posium. Your chance to bring AI down to earth.

Part of TI's commitment to AI is to help you bring together the interested and involved parties in a major educational event — our third AI Satellite Symposium.



A simple hookup brings leading AI authorities into your own facilities to help you understand the latest developments and most profitable new applications — at no charge from TI.

To date, more than 85,000 managers, engineers and technologists representing hundreds of companies, laboratories, universities and other organizations have participated in this series. And a remarkable 94% said it increased their understanding of how to apply AI to their businesses.

Bring leading AI authorities into your own facilities. Free of charge.

On April 8, 1987, we'll be presenting our third symposium, "An AI Productivity Roundtable," broadcast throughout North America, Europe and parts of Latin America. In about four hours, you, your managers and your technologists will explore the newest AI technologies and their practical applications. Leading authorities will help you understand how and why corporations are investing in AI, the risks and the rewards, the emerging trends and the most promising potentials. There's no charge from TI to receive this broadcast. All you'll need to participate is the equipment to downlink the satellite signal.

Everything you need for your AI initiative.

Once you're ready to strategically exploit AI's potential, TI provides a unique resource. We've assembled the

industry's broadest array of AI products and services and can provide a wide range of solutions to satisfy almost any level of interest and investment — from our Personal Consultant™ Easy expert system software at under \$500* to our advanced Explorer™ AI workstation to a full strategic-level AI initiative.



"Texas Instruments has made a major, long-term commitment to Artificial Intelligence. We have applied AI aggressively to our own productivity and products. And now we are helping our customers realize AI's potential through a wide range of products, services and support."

Jerry R. Junkins

— Jerry R. Junkins
President and Chief Executive Officer

How to find out more.

Let TI help you understand how AI can make your organization a tougher competitor. For information on the symposium and our AI capabilities, just call 1-800-527-3500 or write: Office of the President, Data Systems Group, Texas Instruments, Mail Station 2068, P.O. Box 2909, Austin, Texas 78769.


**TEXAS
INSTRUMENTS**

At Texas Instruments, we've already put AI to work under a company-wide strategy we call Knowledge Technologies™. This is a combination of real products, programs, people and tools capable of helping you achieve practical applications of AI in your business. Right now.

Knowledge Technologies, Personal Consultant and Explorer are trademarks of Texas Instruments Incorporated.

* Suggested list price.

31642
© 1987 TI

COMING ATTRACTION

They said everyplace was the same. Then they got a view of the future,
And suddenly, nothing was the same...

COLUMBIA, SC WHAT THE FUTURE IS COMING TO:

"Our TOWER computer, one of the hottest products in the industry, was conceived, designed, developed and manufactured here in Columbia."

Allan M. Quick
General Manager
NCR E&M-Columbia

"We're excited about Columbia's new performing arts center and our part in getting it started. Of course, as a business investor, we've put millions of dollars to work there and always with great results."

Ira Koger
Chief Executive Officer
Koger Properties

"A location for a corporate headquarters depends on excellence—in the community and in its people. We found it here from the beginning and it just keeps getting better."

Gayle O. Avery
Chairman of the Board
Colonial Life and Accident
Insurance Co.

Once you've seen it, you may never be the same again, either.

Fairfield, Lexington And Richland Counties Present "COLUMBIA, SC. WHAT THE FUTURE IS COMING TO"

Starring: A RECESSION-PROOF ECONOMY ★ NINE INSTITUTIONS OF HIGHER LEARNING
★ A WILLING, LOYAL WORK FORCE ★ THE MOST EFFICIENT INTERSTATE SYSTEM IN AMERICA
★ SWEARINGEN ENGINEERING CENTER ★ A PARTNERSHIP BETWEEN BUSINESS AND GOVERNMENT
★ COLLEGE AND PROFESSIONAL SPORTS ★ 50,000-ACRE LAKE MURRAY.

Produced And Directed By The GREATER COLUMBIA CHAMBER OF COMMERCE.

For a view of what the future is coming to, contact Danny Fore (803) 733-1110.



16



28



36



52

FEATURES**ARTIFICIAL INTELLIGENCE GOES TO WORK**

16

From finance to aerospace, tools such as expert systems are making their mark

CHEMICAL MAKERS GET IN SHAPE FOR THE '90s

28

As the industry matures, it is forging new strategies to avoid the fate of American steel

GETTING A HANDLE ON PORTABLE COMPUTERS

36

Laptop PCs are catching up with desktop models, but size/performance trade-offs persist

DIAMONDS FIND NEW SETTINGS

44

Ultrahard coatings could lead to better cutting tools, computer disks, and lasers

DEPARTMENTS

Opinion	Unblocking the flow of capital	6
Letters	Technology and nature; Through rain and snow and fluorescent paint	7
Innovations	Network runs on phone lines; Monitoring bone disease; Dive computer	8
Insights	Wanted: hands-on engineers	10
Business strategies	Fast forward in voice processing; Expanding the bioprocessing market; Diversifying into systems integration	12
Industrial	CT scanners seek out manufacturing flaws	50
Consumer	The big screen comes home	52
Military/Aerospace	Ceramic turbines for cars could wind up on planes	56
Business	Turning television into a business tool	60
Perspectives	Earning degrees via satellite; Voice compression for digital networks; Moth's eyes inspire advances in optical devices	63
Resources		65
TechStarts	Athens Corp.; Quadtree; Myriad Concepts	67
Investments	Machine vision broadens its horizons	68
Cover	Laurel Miller, Site Manager for Credit Authorization, and Bob Flast, VP of Technology, American Express Travel Related Services Co. Photo by Bill Ballenburg.	

COPYRIGHT © 1987 by High Technology Publishing Corporation. All rights reserved. Editorial and executive offices at 38 Commercial Wharf, Boston, MA 02110. HIGH TECHNOLOGY (ISSN: 0277-2981) is published monthly by High Technology Publishing Corporation, 38 Commercial Wharf, Boston, MA 02110, and is intended for persons who hold technology-management and related positions. No subscriptions granted without complete identification, including subscriber name, title, job function, company or organization name, and primary activity of company or organization. Publisher reserves right to determine whether qualified or non-qualified price applies. U.S., U.S. possessions, and Canada qualified rate: 12 issues \$30, 24 issues \$50, 36 issues \$60, payable in U.S. currency. Non-qualified U.S. and Canada: 12 issues \$40. All other countries: 12 issues \$60, payable in U.S. currency. All subscription correspondence should be addressed to David Patterson, HIGH TECHNOLOGY Magazine, P.O. Box 2810, Boulder, CO 80322, 1-800-525-0643. Please allow six weeks for change of address. Include your old address as well as new and, if possible, enclose an address label from a recent issue. Second class postage paid at Boston, MA, and additional mailing offices. Postage paid at Mississauga, Ontario. POSTMASTER: send address changes to HIGH TECHNOLOGY Magazine, P.O. Box 2810, Boulder, CO 80322. Material in this publication may not be stored for electronic distribution or reproduced in any form without permission. Request for permission should be directed to Permissions Manager, HIGH TECHNOLOGY, 38 Commercial Wharf, Boston, MA 02110. High Technology is a registered trademark of High Technology Publishing Corporation.

NEC NEWSCOPE



"NEXTAR" MINI EARTH STATION NETWORK.

Private Ku-band satellite communications networks using mini earth stations on customer premises are poised to take off in the US.

Our advanced mini earth station networking system "NEXTAR" offers unprecedented flexibility for transaction-oriented businesses typically using POS, ECR and ATM systems.

The NEXTAR provides interactive data communications between a central hub and many widely-dispersed remote mini earth stations

in a "star" network topology. Our exclusive Adaptive Assignment TDMA system automatically assigns the best pathway for each data message to minimize response time for short interactive messages and increase throughput during long batch transmission. NEXTAR transparently interconnects existing remote terminals and the host's front-end processor thanks to its intelligent network features.

The mini earth station, a 1.2 or 1.8m

antenna with an integral RF package and compact indoor unit, takes less than a workday to install. Site selection and licensing are also simplified with the Ku-band. The central hub station with comprehensive monitoring, control and diagnostic capabilities can be located adjacent to a data center or at a shared site.

The NEXTAR network can be custom-tailored to a user's exacting needs—data rates from 75bps to 56Kbps plus voice and video capability. It eliminates the wasted transmission capacity and high cost of traditional alternatives.

NUMBER 137

1.3-MICRON OEICs FOR GIGA-BIT LINKS.

Scientists at the NEC Optoelectronics Research Laboratory have successfully tested the world's first optoelectronic ICs to operate in the 1.3 μ m band at data rates of 1.2Gbps.

The optical transmitter and receiver chip pair set records of a 12-km communication at 1.2Gbps with a 7.7dB margin, and 22-km transmission at 565Mbps with a 9.9dB margin in the experiment using a single-mode fiber.

The new light-emitting chip incorporates a 1.3 μ m DC-PBH (double-channel planar buried heterostructure) laser diode and three InGaAsP/InP hetero-junction bipolar transistors on the same InP substrate. Modulation up to 2Gbps is possible in NRZ mode. A peak output of 20mW was marked at 1Gbps.

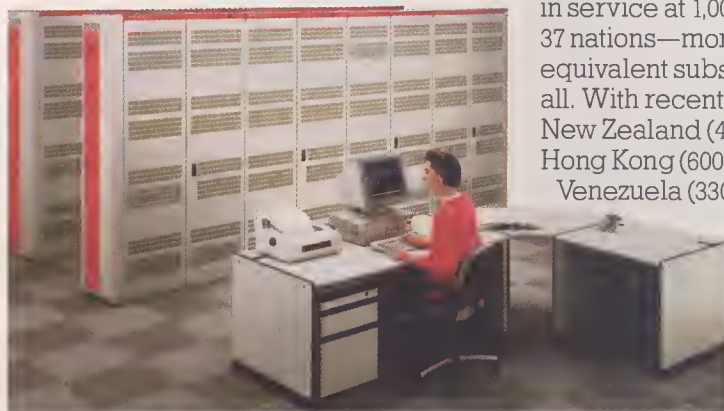
The optical receiver integrates a PIN photo diode and three low-noise InGaAsP junction FETs on a single chip for sensitivity of -14dBm at 1.2Gbps.

NEC's new OEIC pair will be the ideal workhorse in medium- or short-distance ultra-high speed links including LANs, local subscriber loops and interconnections of computers and peripherals because it promises much lower cost and smaller size than prevalent discrete devices.

These OEIC devices will reach the market within a few years.

NEAX61 NOW IN SERVICE AT 1,002 EXCHANGES.

Our NEAX61 digital switching system continues to play a key role in the phenomenal



expansion of digital networks around the world.

Since its implementation in 1979 the NEAX61 has captured the attention of telecommunications administrators worldwide for its sophisticated modular hardware and software, advanced service features, and full operation and maintenance support.

Today there are NEAX61 switches in service at 1,002 exchanges in 37 nations—more than 5 million equivalent subscriber lines in all. With recent orders from New Zealand (400,000 lines), Hong Kong (600,000 lines) and Venezuela (330,000 lines) the

aggregate orders received now exceeds 10 million equivalent subscriber lines.

NEC OPTICAL REPEATERS GO TRANSPACIFIC AND SUBMARINE.

The trend in transoceanic submarine cable systems is undeniably "optical". The use of fiber optic transmission technology increases capacity, extends repeater span and ensures compatibility with land-based digital networks.

Under a contract awarded by KDD, Japan's leading international telecommunications network, NEC is manufacturing optical submarine repeaters and optical terminal equipment for the third Trans-Pacific Cable (TPC-3) which will link Hawaii and Japan with a branch to Guam.

The TPC-3, to be completed in 1988 and owned by 22 telephone operating companies in 10 countries, will have two 280Mbps systems, offering a total capacity equivalent to 7,560 telephone channels—a dramatic increase from 138 channels with TPC-1 and 845 channels with TPC-2.

Incorporating our 1.3 μ m DC-PBH (double-channel planar buried heterostructure) laser diodes and newly-developed high-speed monolithic ICs, the optical repeaters are designed to maintain high reliability on the ocean floor at a depth up to 8,000 meters.

NEC

UNBLOCKING THE FLOW OF CAPITAL

It's interesting to contrast the United States with Japan and Korea in the uses of capital. Giant Japanese companies, and a few Korean conglomerates, tend to seek big shares of growing global markets rather than a quick return on investment. They invest heavily in efficient mass production while simultaneously building sales volume; early losses are tolerated in anticipation of high returns later.

This high-risk strategy requires financial strength. The Japanese *zaibatsus* and Korean *chaebols* include banks or similar financing arms that can make long-term loans at low interest rates to carry out capital investment programs (which are viewed as good for the nation as well as for the company involved). Government policies help keep interest rates low enough to encourage such investment.



In the U.S., even large conglomerates tend to back away from riskier, future-oriented investments in high technology enterprises, especially when business softens. Even in good times, the cost of capital is much higher in the U.S. than it is abroad. U.S. interest rates have declined recently, but they remain far above those of some major trading partners. So when American companies do launch innova-

tive ventures, they frequently build their new plants abroad.

Venture capital in the U.S. can also prove counterproductive at times. As a new technology gets "hot," whole development groups are pulled out of existing companies to form a host of start-ups, all vying for the same markets. It's common for them to run short of cash before they achieve market success, and investors may become wary as they see a proliferation of similar enterprises. What often follows is bailouts of struggling start-ups by overseas giants in return for their innovative technology.

These are tough problems, some without clear-cut solutions. But the U.S. must find ways to change the incentives for capital investment or it will continue to lose markets and even whole industries to overseas competitors. Here are some suggestions:

- Federal deficits must be dramatically cut, because the government's competition with the private sector for capital keeps the price of borrowing high. The military budget and extravagant multibillion-dollar projects (such as the space station) need reevaluation. The U.S. provides defense shields in Europe and in the Far East; allies should play a stronger role in their own defense.
- Low-cost loans should be available for buying productivity-enhancing equipment, just as the Export-Import Bank makes loans to help U.S. companies finance projects abroad.
- Tax incentives should be shifted to reward savers rather than borrowers, in order to provide more capital for investment.
- The Commerce Department could do more, in cooperation with the states, to help disseminate information on successful industrial-development programs across the country, and to educate smaller manufacturers, particularly on ways to improve productivity.

Robert Haavind
Robert Haavind

HIGH TECHNOLOGY

EDITOR
Robert C. Haavind

EXECUTIVE EDITOR, Steven J. Marcus
SENIOR EDITORS, Jeffrey Bairstow, Herb Brody,
Dwight B. Davis, H. Garrett DeYoung,
Peter Gwynne, Jeffrey Zygmunt
SENIOR BUSINESS EDITOR, Dennis Livingston
MICROCOMPUTER EDITOR, Cary Lu
ASSOCIATE EDITOR, Salvatore Salamone
CONTRIBUTING EDITOR/AEROSPACE, Philip J. Klass
COPY EDITOR, David Brittan
PRODUCTION EDITOR, Margaret Woisard
EDITORIAL RESEARCHER, Cindy Rainey
EDITORIAL PRODUCTION MGR., Susan McCabe
ADMINISTRATIVE ASSISTANT, Helen Wheeler
CONTRIBUTORS, Dana Blankenhorn, Sam Diamond,
Terry Feldt, David H. Freedman, Gordon Graff,
G. Berton Latamore, Ricki Lewis, Peter W. Mitchell,
Mark Patiky, Roger W. Redmond, Roland W. Schmitt,
Tim Smart, Steven Weissman
ART DIRECTOR, Anne C. McAuliffe
PHOTO RESEARCHER, Sharon Hopwood
ART ASSISTANT, Paul Weston
ILLUSTRATOR, Mark E. Alsop

PUBLISHER/VICE-PRESIDENT
Thomas H. King

CIRCULATION MGR., Mark H. Hollister
SUBSCRIPTION SERVICE, Alison White
MANUFACTURING DIRECTOR, Janet M. Kelly
PRODUCTION MGR., Rebecca Stewart
MGR. OF SUBSIDIARY PUBLISHING, Elizabeth Seaman
PERMISSIONS & REPRINTS MGR., Elizabeth Longworth
PUBLIC RELATIONS DIRECTOR, Sherwood Ross
ADVERTISING DIRECTOR, Jim Cerbone
SALES & MARKETING OPERATIONS MGR., Debi Smith
PROMOTION & RESEARCH MGR., Kim L. Fleischauer
DIRECT MARKETING/RECRUITMENT/
CLASSIFIED SALES MGR., Linda A. Conti

U.S. SALES OFFICES

Boston Garland Assoc., Inc. 10 Industrial Park Rd. Hingham, MA 02043 Jack Garland Peter Hardy (617) 749-5852	Jacksonville J. M. Cerbone & Assoc. 504 N. Dixie Freeway New Smyrna Beach, FL 32069 (904) 427-0356
Chicago, St. Louis, Minneapolis T. F. Marketing Assoc. 1496 County Farm Ct. Wheaton, IL 60187 Tom Fitzpatrick (312) 653-1611 Nancy Brown (312) 281-3403	New York Desmond Abicair Arthur Santucci 342 Madison Ave., Suite 1230 New York, NY 10173-0049 (212) 687-6715
Dallas, Denver Marcus A. Loy and Assoc., Inc. 14114 Dallas Parkway Suite 245 Dallas, TX 75240 (214) 788-2939	Los Angeles A. Carroll Walters 1642 Westwood Blvd., Ste. 202 Los Angeles, CA 90024 (213) 474-3332
Detroit Donald L. Rowe & Assoc. 2685 Lapeer Road, Suite 207 Auburn Hills, MI 48057 (313) 373-3950	San Francisco Forsiak & Assoc., Inc. P.O. Box 2649 San Anselmo, CA 94960 (415) 461-8366

INTERNATIONAL SALES OFFICES

Asia/Pacific China Consultants Int'l, Ltd. Suite 905, Guardian House 32, Oi Kwan Road Happy Valley, Hong Kong Tom Gorman (852) 5-833-2181 Telex: 75368-AMR HK HX	Canada Victor Brown & Assoc., Ltd. 15 Zorra St. Toronto, Ontario M8Z 4Z6, Canada (416) 259-9631 Telex: 06-984747
ASCH Corporation FFF Bldg 6-11-1 Minami Aoyama Minato-Ku Tokyo, 107 Japan Mr. Geoff Leach Mr. Toshiaki Sato (81) 3-797-3464 Telex: J28764-ASCH	Europe Julespage, Ltd. 37 Sussex St. London SW1V4RJ England Joseph C. Page, Jr. (011) 441-834-4028 Telex: 8814861 CCI
Korean Int'l Adv. Svcs., Ltd. C.P.O. Box 9109 Seoul 100, Korea Mr. Jeh-Nam Song (82) 2-779-1538/9	Caribbean, Central America Furey & Associates 210 East 47th St., Suite 11F New York, NY 10017 (212) 355-7034

Published monthly by High Technology Publishing Co.,
38 Commercial Wharf, Boston, MA 02110.

Chairman, Bernard A. Goldhirsh, Senior Vice-President,
Joel Novak; Vice-President, William C. Taylor; Treasurer,
John W. Carlson; Controller, John J. Reardon

Save up to \$48.

- ☐ **Save \$48:** 36 issues of High Technology for \$60.
That's \$48 off the newsstand price.
- ☐ **Save \$6:** 12 issues of High Technology for \$30.
That's \$6 off the newsstand price.

☐ Bill me. ☐ Payment enclosed.

ITEMS 1-8 MUST BE COMPLETED BEFORE
SUBSCRIPTION CAN BE ENTERED.

1. NAME _____

2. TITLE _____

3. COMPANY _____

4. ADDRESS _____

5. CITY/STATE/ZIP _____

Mail subscription to: ☐ Company ☐ Home

Home Address _____

City/State/Zip _____

Those not qualifying may pay more than the basic rate. Please allow 4-6 weeks for delivery of the first issue. One year subscription to Canada: \$30 (US). All other foreign: \$60 (US). Basic rate: 12 issues \$30.

6. INDICATE THE TYPE OF BUSINESS AT YOUR LOCATION. CIRCLE ONLY ONE.

Manufacturing
Major Product of
Company or Division:
A Chemicals or Allied Products
B Machinery
(Except Electrical)
C Electrical or
Electronic Equipment
D Computers/Peripherals
E Transportation Equipment
F Measuring/Controlling
Instruments
G Other: _____

H Government or Military
I Construction/Engineering
J Services
Please Note Type:
K Computer or Software
L Other: _____

M Communications
N Transportation
P Banking/Finance
Insurance
Q Other: _____

7. INDICATE YOUR LEVEL OF RESPONSIBILITY.

A Top Management (Owner, Chairman, President, Executive or Senior Vice President, Vice President)
B Senior Operations and Financial Management (Division Head, Department Head, Profit Center Manager, etc.)
C Professional/Technical Management and Staff (Group Leader, Project Manager or Equivalent)

8. FUNCTIONAL RESPONSIBILITY (CIRCLE ONE ONLY)

A Business/Financial/Administrative
B Design/Engineering
C Manufacturing/Production/Operations
D Systems Information (MIS/EDP/Communications)
E Systems Integration/Technical Support
F Research & Development
G Other: _____

4CCE6

Pay as little as \$30.

- ☐ **Save \$48:** 36 issues of High Technology for \$60.
That's \$48 off the newsstand price.
- ☐ **Save \$6:** 12 issues of High Technology for \$30.
That's \$6 off the newsstand price.

☐ Bill me. ☐ Payment enclosed.

ITEMS 1-8 MUST BE COMPLETED BEFORE
SUBSCRIPTION CAN BE ENTERED.

1. NAME _____

2. TITLE _____

3. COMPANY _____

4. ADDRESS _____

5. CITY/STATE/ZIP _____

Mail subscription to: ☐ Company ☐ Home

Home Address _____

City/State/Zip _____

Those not qualifying may pay more than the basic rate. Please allow 4-6 weeks for delivery of the first issue. One year subscription to Canada: \$30 (US). All other foreign: \$60 (US). Basic rate: 12 issues \$30.

6. INDICATE THE TYPE OF BUSINESS AT YOUR LOCATION. CIRCLE ONLY ONE.

Manufacturing
Major Product of
Company or Division:
A Chemicals or Allied Products
B Machinery
(Except Electrical)
C Electrical or
Electronic Equipment
D Computers/Peripherals
E Transportation Equipment
F Measuring/Controlling
Instruments
G Other: _____

H Government or Military
I Construction/Engineering
J Services
Please Note Type:
K Computer or Software
L Other: _____

M Communications
N Transportation
P Banking/Finance
Insurance
Q Other: _____

7. INDICATE YOUR LEVEL OF RESPONSIBILITY.

A Top Management (Owner, Chairman, President, Executive or Senior Vice President, Vice President)
B Senior Operations and Financial Management (Division Head, Department Head, Profit Center Manager, etc.)
C Professional/Technical Management and Staff (Group Leader, Project Manager or Equivalent)

8. FUNCTIONAL RESPONSIBILITY (CIRCLE ONE ONLY)

A Business/Financial/Administrative
B Design/Engineering
C Manufacturing/Production/Operations
D Systems Information (MIS/EDP/Communications)
E Systems Integration/Technical Support
F Research & Development
G Other: _____

4CCE6

the replica's noble self-sacrifice (by publicly crashing) will not have been in vain.

Paul B. MacCready
Chairman of the Board
AeroVironment
Monrovia, Cal.

represent only a marginal improvement over the shuttle." However, a 1977 Rockwell study showed that Star-Raker payloads from 196,000 pounds to 277,900 pounds could have been carried into a 300-nautical-mile Space Shuttle-type orbit. These payloads, from 3.9 to 5.6 times that

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110. Or send to MCI Mailbox: HIGHTECHLET, (617) 262-6468.

JEFF CORWIN



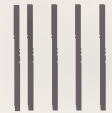
NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

Business Reply Mail

*First Class Permit No. 68, Boulder, Colorado
Postage will be paid by:*

HIGH TECHNOLOGY

*P.O. Box 2808
Boulder, Colorado 80321-0001*



NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

Business Reply Mail

*First Class Permit No. 68, Boulder, Colorado
Postage will be paid by:*

HIGH TECHNOLOGY

*P.O. Box 2808
Boulder, Colorado 80321-0001*



opment programs across the country, and to educate smaller manufacturers, particularly on ways to improve productivity.

Robert Haavind
Robert Haavind

Korean Int'l. Adv. Svcs., Ltd.
C.P.O. Box 9109
Seoul 100, Korea
Mr. Jeh-Nam Song
(82) 2-779-1538/9

Caribbean, Central America
Furey & Associates
210 East 47th St., Suite 11F
New York, NY 10017
(212) 355-7034

Published monthly by High Technology Publishing Co.,
38 Commercial Wharf, Boston, MA 02110.

Chairman, Bernard A. Goldhirsh; Senior Vice-President,
Joel Novak; Vice-President, William C. Taylor; Treasurer,
John W. Carlson; Controller, John J. Reardon



Paul MacCready and friend.

Harmony between technology and nature

Your sidebar "Paul MacCready: Aviation's part-time pioneer" (Dec. 1986, p. 32) stated that our flying replica of a giant pterodactyl was "developed to promote the film *On the Wing*" and "met a spectacular end." The pterodactyl was actually a key actor in the film, making many flawless flights in Death Valley before the cameras. Months later this temperamental, overweight adolescent crashed spectacularly in front of a crowd, but that was not its end. Within three hours of the crash, our first aid restored it to relatively good health, and two days later it was ensconced at the National Air and Space Museum, where *On the Wing* is currently being shown.

The pterodactyl replica is a metaphor representing the connection between nature's evolution of flight and man's aeronautical developments. The fact that it flew comfortably in the wilderness habitat but crashed (due to a spurious radio signal) when forced into man's crowded domain, can be considered a related metaphor—the impact of man on nature.

The film attempts to give the audience a basis for contemplating the relationship between nature and man—a perspective on which civilization's possible successful future depends. If millions see the film, the replica's noble self-sacrifice (by publicly crashing) will not have been in vain.

Paul B. MacCready
Chairman of the Board
AeroVironment
Monrovia, Cal.

Through rain and snow and fluorescent paint

The closing paragraph of "Guided vehicles set manufacturing in motion" (Dec. 1986, p. 16) referred to the potential market of AGV applications in the office. Our Mailmobile is already there. It delivers interoffice mail and operates on an invisible fluorescent guideway that you described in your article. Over 1000 Mailmobiles are presently in use.

Michael Pallmer
Product and Chemical Engineering Mgr.
Bell & Howell Mailmobile Operations
Zeeland, Mich.

Versatile satellites

Your article "Satellite communications at down-to-earth prices" (Dec. 1986, p. 38) addressed only one subsegment of the VSAT market—interactive data applications. Our company is the only one in the industry that offers services to the entire spectrum of VSAT applications, including voice, broadcast video, point-to-point data, combined voice/data, and interactive data. We anticipate operational networks in these areas by mid-1987.

John Mattingly
Director of Marketing
American Satellite
Rockville, Md.

The Space Shuttle that might have been

In "Launching the aerospace plane" (July 1986, p. 46) you state that the proposed 1977 Rockwell International aerospace plane called Star-Raker would have had a payload of 126,000 pounds when carried to orbit, and that "such a behemoth would represent only a marginal improvement over the shuttle." However, a 1977 Rockwell study showed that Star-Raker payloads from 196,000 pounds to 277,900 pounds could have been carried into a 300-nautical-mile Space Shuttle-type orbit. These payloads, from 3.9 to 5.6 times that

of the shuttle, thus represent a significant improvement.

The Star-Raker concept, which I created in 1966, dropped out of the shuttle competition because it required turboramjet engines that did not exist at the time. Later on, it was discovered that the supersecret Lockheed SR-71 "Blackbird" engines could have been used for the Star-Raker design. Perhaps Star-Raker would have been the Space Shuttle!

David A. Reed, Jr.
Anaheim, Cal.

Mr. Reed, now retired, was formerly a member of the technical staff of Rockwell/North American's preliminary design group.

U.S. first in tilt-rotor planes

Hugh A. MacLean's letter "Canada first?" (Dec. 1986, p. 5) asked if the similarity between the 1965 Canadair CL-84 Dynavert and the Bell-Boeing V-22 Osprey is the result of the continuing brain drain from Canada to the U.S. Perhaps he overlooked the fact that Bell Helicopter's XV-3 Convertiplane completed the first 100% tilt-rotor conversion flight in 1958. Bell Helicopter has been working on a series of tilt-rotor aircraft since 1955, including the XV-15, V-22, and XV-3. Other companies such as LTV, Canadair, and Convair have attempted tilt-rotor or tilt-wing, but have not been able to make it work.

Milan E. Anich
Amarillo, Tex.

In "Energy-wise buildings" (Feb., p. 36), PPG Industries was incorrectly identified by its former name, Pittsburgh Plate Glass. Also, in Resources (Feb. 1987, p. 65), the phone number for the Society of Manufacturing Engineers should have been listed as (313) 271-1500.

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110. Or send to MCI Mailbox: HIGHTECHLET, (617) 262-6468.

INNOVATIONS

Office network operates on phone lines

A novel approach to office communications promises to bring integrated voice and data networking within reach of businesses that could not otherwise afford it. Network products from Telegence, a start-up company in Westlake Village, Cal., modulate voice and data transmissions at different frequencies, allowing both to be sent (in analog form) over a company's existing telephone lines.

Although the transmission rate (1 megabit per second) is lower than that of some local-area networks, or LANs—the popular Ethernet operates at 10 Mbps—it far outstrips the 19,200-bps rate common on telephone PBX systems. What's more, companies avoid the expense of putting in a labyrinth of coaxial cable—a major drawback of some LANs. Instead, they simply connect a small interface unit to a telephone and to a terminal or computer. A single phone/terminal combination can be hooked up for about \$600, and if several devices are close together, they can share an interface for about \$130 per connection. In contrast, conventional local-area network connections typically cost \$400–\$1000.

Like IBM's widely used local networking scheme, the Telegence system employs token passing, in which an empty slot, or token, reaches each networked station at a set interval so that each station has a guaranteed access time. In addition, it emulates a ring topology, the type of architecture popularized by IBM. But the network's physical layout closely matches the star shape of the PBX systems it is meant to enhance; at the center of the network is a "token hub" device, which separates the voice and data signals sent by stations as far away as 1000 feet and passes them on to the proper destination.

According to Telegence, the voice channels work even if the data channels are not running, and a single network can support up to 250 interface units, which can handle as many as 4000 communication channels.



According to Telegence president Andrew Richert, existing office phone lines offer a less expensive route to networking.

Computer monitors bone disease

A small Ohio company has devised a low-cost computer technique for detecting osteoporosis, a common hormone-linked disorder of older women in which bones become less dense and thus more prone to fracture. The procedure is reportedly as accurate as more costly methods, and uses ordinary x-ray films, which normally do not depict osteoporosis until it is relatively advanced.

Osteoporosis is usually assessed with scanners called photon absorptiometers, which directly measure bone-mineral density; the devices are priced as high as \$100,000, and a single scan costs the patient up to \$300. By contrast, Clinical Radiology Testing Laboratory (CRTL) in Yellow Springs, Ohio, offers the services of its new system for \$65 per analysis.

In the CRTL method, called radiographic absorptiometry, an x-ray is taken of the patient's hand; the fingers are thought to provide a window into osteoporosis because they contain both compact and spongy bone. The film is then sent to CRTL, where the image is digitized and read into a computer. The lab's software automatically deletes extraneous tissue such as skin and muscle, and determines bone-mineral content by measuring the image density down the finger in 1-millimeter "slices." According to CRTL president Richard L. Hansen, the scans uncover mineral losses of as little as 8–10%; as a rule, x-rays alone do not reveal losses of less than 30%.

Some 45 million American women are at risk for osteoporosis. However, recent studies suggest that the condition may be controlled with diet, exercise, and hor-

monal regimens and thus should be monitored regularly. The findings have dramatically boosted the demand for osteoporosis screening; in fact, the number of screening sites jumped from 25 in 1984 to more than 500 last year. Hansen predicts that by 1990 the exams will be as routine as the Pap smears used to detect cervical cancer.

Wrist computer aids divers

In diving, what goes down must come up—slowly. If divers ascend too fast from the ocean depths, they get the bends, a hazardous accumulation of gas bubbles in the blood. To reduce the danger, a group at Battelle Memorial Institute (Columbus, Ohio) is developing a miniature underwater computer that will give divers precise instructions for returning to the surface. The battery-operated instrument, worn around the wrist, consists of printed integrated circuits mounted on a 1½-inch square of aluminum oxide. On a small display it indicates the current depth, measured by a pressure transducer. At the same time, it calculates the depth to which the diver can safely ascend and the length of time necessary to stay there, on the basis of its record of the dive and the type of gas mixture the diver is breathing. The computer works at depths down to 300 feet.

Battelle is now seeking partners to help commercialize the device. Already, says Milton Seiler, manager for electronic systems and technology, several companies have expressed an interest. Seiler expects that if enough professionals buy the instrument its price will fall low enough to appeal to recreational divers.

Coffee, tea, or telephone?

The group that brought international communications to ocean travel is looking to the sky for its next venture. London-based INMARSAT (International Maritime Satellite Organization) plans to provide worldwide telephone and telex services to and from any commercial aircraft by 1988.

Current air telephone systems, which operate directly between the plane and the ground, are available only in the continental United States. But INMARSAT intends to route calls via the satellites it has in place over the Atlantic, Pacific, and Indian Oceans, thereby providing global coverage. To enable planes to be outfitted for the service with a minimum of difficulty, Racal Antenna Limited (London) has developed a special compact, lightweight antenna that uses relatively simple electronics.

Anticipating a great demand for the service, INMARSAT plans to increase its telephone circuit capacity by launching the first of as many as nine new satellites in 1988. The satellites will be linked to the international public telephone networks through ground stations in England, the United States, the USSR, Argentina, Kuwait, Japan, and Singapore.

The first commercial tests of the air telephone—on British Airways Boeing 747 flights—are scheduled for the end of 1987, and full service is planned for late next year, when the ground stations will be in operation.

"White pages" for electronic mail

Few of the million-plus subscribers to public electronic mail services reap the full advantage from their investment, in part because it's so difficult to find the "addresses" of other people on the networks. There are more than 80 public electronic mail systems in the U.S., few of them interconnecting and each maintaining a separate directory that requires unique access and search commands. In January, however, a new ser-

vice—the National E-Mail Registry (Trevose, Pa.)—began compiling a nationwide listing of electronic mail addresses. Registry president Ken Steele likens the service to the telephone white pages, and hopes it will span all the public electronic mail systems, from small on-line "bulletin boards" to large systems such as Dialcom, MCI Mail, and Western Union's Easylink.

Only people registered on the directory may use it, but registration is free (by calling 800-622-0505 and filling out an electronic form via a 300-, 1200-, or 2400-baud modem with switches set for even parity, seven bits, and one stop bit). Participants receive 50 free searches, after which they can buy a year's unlimited access for \$95 or 50 searches for \$10.

Chemical fights diesel smog

The big, smoky diesel engines found on buses and large trucks are under mounting pressure to clean up their act. Federal guidelines for the '90s call for drastic reductions in both nitrogen-oxide (NO_x) and particulate emissions. In current diesels, you can't reduce one without increasing the other. But a chemical process recently announced at Sandia National Labs in Livermore, Cal., appears to resolve this trade-off.

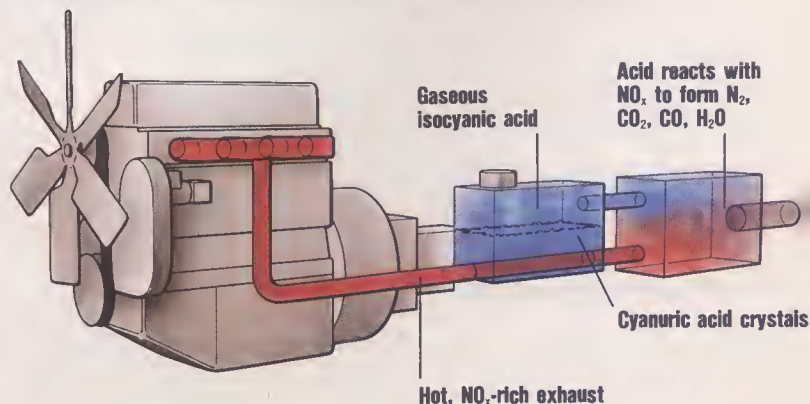
The trouble with heavy-duty diesels is that they run most efficiently at the high

temperatures that cause large amounts of NO_x to form. These emissions are controlled by cooling the engine and delaying fuel injection—methods that lower the engine's efficiency and foul the exhaust with particulates.

The Sandia process, however, stifles NO_x emissions—reducing them by more than 99% in lab tests on a small diesel engine—without increasing particulates. Called Raprenox (for "rapid reduction of nitrogen oxides"), the method was developed by chemist Robert A. Perry with funding from the U.S. Department of Energy. According to Perry, the key to Raprenox is crystallized cyanuric acid, commonly used in swimming pools to stabilize chlorine levels. The acid sits in a chamber connected to the engine's exhaust system. As the hot exhaust flows past the chamber, the chemical evaporates into gaseous isocyanic acid, which neutralizes the NO_x , producing nitrogen, carbon dioxide, carbon monoxide, and water.

Perry, who is forming his own company to develop the system further, says the raw material for Raprenox is inexpensive: a pound of cyanuric acid, enough for perhaps 100 miles of truck travel, costs about 50¢. But he estimates it will take five years or more to get the chemical out of the swimming pool and into the motor pool. For one thing, Perry has yet to find practical ways of installing and replenishing the system. In fact, the first commercial applications will probably be on large stationary industrial diesels, since these pose the fewest design problems.

Purging diesel exhaust with Raprenox



WANTED: HANDS-ON ENGINEERS

ROLAND W. SCHMITT
SENIOR VICE-PRESIDENT AND CHIEF SCIENTIST
GENERAL ELECTRIC CO.

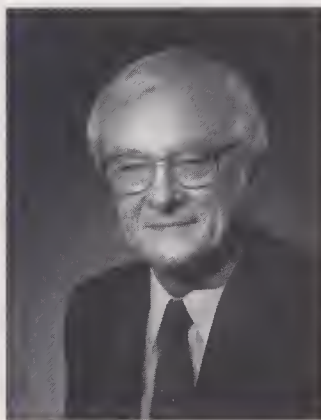
Technologists in the U.S. must rise to two major challenges in order to compete effectively in commercial markets: we must continue to make great leaps of creativity; and we must learn to innovate faster, more efficiently, and with greater attention to quality and manufacturability.

The basis of our creativity, where the U.S. has traditionally excelled, is in danger of eroding. For example, university science and engineering departments lack adequate equipment: National Science Foundation (NSF) surveys show that one-quarter of academic research equipment is obsolete, one-third is more than 10 years old, and less than one-sixth can be called state of the art. Moreover, faculty vacancies are alarmingly high—more than 8%, compared to the usual 3%—and their effect will be especially felt in the 1990s, when the generation trained in the postwar “golden age” of U.S. science and engineering reaches retirement age. Meanwhile, Japan graduates more engineers each year than we do, even though its population is half the size of ours.

Given this situation, how can the U.S. be as inventive as it has been in the past? Some reforms on campus, plus increased involvement in education by industry, are important parts of the answer.

One area where industry-university links are especially crucial is engineering research, which generates much of the knowledge underlying the practice of engineering, and which merges advanced ideas and the ability to use them. A few years ago, many of us became concerned that the nation was falling behind in engineering research. The Committee of Science and Public Policy of the National Research Council, for example, found universities reluctant to grapple with research issues in fields that are basic to advanced automation; it also found them weak in critical fields of materials engineering. In biotechnology, it reported that we are not developing “a knowledge base in process engineering that combines the skills of the biologist and the chemical engineer.”

In response, the NSF created a program of Engineering Research Centers that are explicitly designed to link industry and universities. These bridges will carry



not merely money but, more important, the challenging problems and stimulating people necessary to enrich work at both ends.

Such centers comprise an important step, which must be complemented by other initiatives—for example, universities establishing more interdisciplinary professorships—if American leadership in the creation of new technology is to endure. While I am confident it will, that still only solves half the problem—probably the easier half. There’s also the issue of effective execution—of strong performance all the way to the finish line. Here research is *not* the answer. Although we certainly need cadres of highly skilled engineering researchers, the vast majority of today’s engineers need to be trained less like researchers and more like the practicing, dirt-under-the-fingernails engineers of yesteryear.

By treating everything as a research problem, we tend to derive elegant, inventive solutions without adequate attention to cost, manufacturability, and quality. Meanwhile, the Japanese exercise their skills on features that have significant customer value, while observing stringent guidelines for cost and quality.

The reason for emphasizing theory, at the expense of design and hands-on practice, has been to give the engineering graduate a command of the fundamentals rather than mere exposure to obsolete

machines and superficial shop techniques. That objective is laudable, but its implementation has been carried too far. Students who will work in an economically competitive culture are being trained instead in a culture of research and analysis—the culture of their professors. Thus our educational system imparts mostly academic values, which emphasize optimum solutions, while putting little emphasis on such considerations as speed, cost, and customer satisfaction—the values of the marketplace.

In saying that our engineers need to be trained less like researchers and more like old-fashioned engineers, I don’t mean that we should return to slide rules and drafting tables. The modern practitioner must of course be trained to use modern tools. Computer-aided engineering, for example, can speed up projects. Testing ideas quickly and inexpensively on computer simulations can drastically cut the length and cost of the design cycle, and lead to better-quality products.

Another important new technology is artificial intelligence. With old-fashioned engineers an endangered species, perhaps we should clone them electronically. Using expert systems, it’s becoming possible to capture much of the knowledge of an expert designer, troubleshooter, or manufacturing engineer in a computer program, which can then be an extremely valuable tool for educating or assisting the new engineer.

But we shouldn’t look to technology for all the answers. Serious reforms are needed in engineering education. We need to reinstate some old practices, and introduce some new ones. For example, co-op programs can give students early insights into the realities of their profession. I also believe that the past problems of co-op education—inconsistent support from industry, high management costs, and faulty program design—can be alleviated.

Another idea, proposed by Bernard Friedland of the Singer Corp. and Peter Dorato of the University of New Mexico, is that engineers be trained like doctors and lawyers, and not enter into specialized study until their postgraduate days. Only then will they have the appropriate skills and maturity.

***We tend to derive
elegant, inventive
solutions without ade-
quate attention to
cost, manufacturability,
and quality.***

Even in teaching the fundamentals of engineering, Nam Suh of the NSF points out that you have to choose the *right* fundamentals. In recent years, emphasis has been on analysis (taking things apart) rather than synthesis (putting things together), as though engineering were analyzing a man-made universe in which design and manufacturing could be taken for granted.

It may turn out that the only way to learn synthesis and become a good engineering designer is by experience—by creating a lot of designs and learning something from each, especially the bad ones. But I would hope for a more efficient method. Nam Suh has another good suggestion: provide engineers with the equivalent of a medical school's teaching hospital.

Finally, I believe we should keep work-

ing on industry-university interactions of all kinds, and not just as vehicles for more financial support. "Don't just send money," the president of one well-known university recently remarked. "Send us the best people who have thought deeply about the process, and send them not just for a day or a week, but full-time for months."

Right now, we can point to a substantial number of industry people who will move on to academic careers. But a closer look shows that they are quite often the ones who already resemble professors in

their outlooks and activities. The masters of engineering execution in industry rarely have the opportunity or inclination to spend much time on campus. But we should find better ways to attract them, as well as to justify their teaching roles to the companies that pay their salaries. Similarly, I have considerable sympathy with the proposal that working on manufacturing and design problems in industry—directly on the factory floor—should count as much as an assistant professor's tenure hearing as theoretical papers published in professional journals.

The idea is not to stop learning the fundamentals of engineering, but rather to ensure that engineers know how to use those fundamentals, and are motivated to satisfy not just themselves and their technical colleagues but also their customers and clients. □

HOW TO READ THE JAPANESE.

It's actually quite simple. You can acquire the most current, vital findings of Japanese research — in a way that's far easier than reading them in Japanese.

Because now there's the Japanese Technical Information Service (JTIS), from UMI.

When your organization subscribes to JTIS, you receive monthly summaries in English from more than 700 Japanese publications. All

areas of applied technology and business in which Japan is prominent are covered, including microelectronics, computer technology, biotechnology, aerospace engineering, quality control, business management, finance, ceramics, defense, and more.

Now you can finally learn about the latest Japanese advances in technology and business — without spending years learning how to read Japanese.

ANNOUNCING two new services for JTIS subscribers!

Full-text article translations and document delivery! For more information, send in the coupon below. To save time, call us toll-free 1-800-521-0600 (U.S.), 1-800-343-5299 (Canada).

Circle No. 39 on Reader Service Card.

U·M·I Japanese Technical
Information Service

University Microfilms International
A Bell & Howell Information Company
300 North Zeeb Road Ann Arbor Michigan 48106

**FREE
sample
available!**

Call
**1-800-521-0600
1-800-343-5299**

- ☐ Yes, I'd like to read the Japanese. Please send me more information on JTIS and a free sample right away.
- ☐ Yes, I'm also interested in your new translation and document delivery services. Please send me information on this as well.

Name

Title Phone

Address

City State Zip

OCTEL COMMUNICATIONS:

FAST FORWARD IN VOICE PROCESSING

Voice-processing equipment is finding increasing use in large firms as a means of both eliminating telephone tag and communicating product information and customer inquiries more efficiently between individuals in the field and central offices. For instance, voice systems are used at Protective Life Co. (Birmingham, Ala.) to inform several hundred managers of forthcoming staff meetings with one phone call broadcast to their voice mailboxes, and at the *Dallas Morning News* to tell deliverymen when subscribers call in complaints about not getting their papers.

Both firms use products from Octel Communications (Milpitas, Cal.), which claims to have solved a problem that had previously constrained the industry. Voice-processing equipment connects with the private branch exchanges (PBXs) that route incoming telephone calls; but "most large companies have more than one brand of PBX," says Robert Cohen, Octel's president, "so they want a voice message system that can work companywide, with high quality and a breadth of features." By offering systems compatible with a variety of PBXs, including those made by AT&T and IBM's Rolm subsidiary, Octel has quickly become a leader in voice processing.

Octel, founded in 1982, has implemented its strategy with the Aspen (Automatic Speech Exchange Network) product line. For example, the Aspen Maxum, which began shipping last November, is the first voice-processing system that supports up to 7500 users on a single PBX; equivalent systems from competitors must be attached to multiple PBXs to achieve such performance, according to Octel. Among its features, Maxum allows a business to create a customized menu that directs callers to various components of the system, such as direct dial of extension numbers and access to periodically changing company messages. In addition, the WooBox, named for Octel engineer Donald Woo, lets Aspen systems connect to devices like the old AT&T Dimension PBX, which still has the largest installed base in the PBX market. In 1986, Octel also began shipping Aspen models compatible with Rolm's CBX, one of that firm's best-selling PBX

systems. Octel's customers include GE, Hewlett-Packard, and other large companies.

Octel's market offers good opportunities for further growth. Revenues for voice-processing equipment were an estimated \$210 million in 1986, according to Probe Research (Morristown, N.J.), and should grow at 30% per year through 1990. One-quarter of that market is held by Rolm, but Octel is gaining on the leader—its market share nearly doubled to 11% in 1986, as a result of its PBX-compatibility strategy. Octel, a private company, acknowledges revenues of about \$15 million for the fiscal year that ended in June 1986, and company officials hope to double that figure this year.

Karl Kozarsky, a vice-president at Probe, believes that Octel will continue to be a rising star. "It has a very competitive line, and it has done a good job in showing



Octel makes voice-processing equipment compatible with a wide variety of PBXs, says president Robert Cohn.

potential customers specific cost savings available from specific applications." □

—Dana Blankenhorn

ENGENICS:

EXPANDING THE BIOPROCESSING MARKET

Over the past decade, biotechnology companies have sought commercial success by purifying and scaling up the production of pharmaceuticals and chemicals derived from cloned genes or cultured cells. Engenics (Menlo Park, Cal.) was founded in 1981 to provide such firms with contract R&D services that facilitate those efforts; such services include increasing chemical yields from microorganism strains, developing fermentation media and bioreactors for particular products, and developing product purification processes. For example, Engenics designed a process for one client to convert a sugary byproduct of wood into useful alcohols and organic acids; for

another, it designed a process by which specialty chemicals could be produced by manipulating enzymes in a bioreactor.

"Initially we thought that it would be worthwhile to go after the large pharmaceutical firms and biotech start-ups," says John L. Richardson, Engenics' president. "However, we learned that the former can often do their research internally, while start-ups may not have the financial resources and continuing commitment necessary for our services." So in order to keep growing, the company is focusing on two types of customers: Fortune 500 firms outside the traditional biotech field but with involvement in such products as specialty chemicals, materials, and foods and



NOW ONE OF YOUR MECHANIC'S TOOLS IS ANOTHER MAN'S MIND.

At GM, we think of computers in human terms. Because today, we have begun to program human knowledge—and logic—into a computer. It's called artificial intelligence.

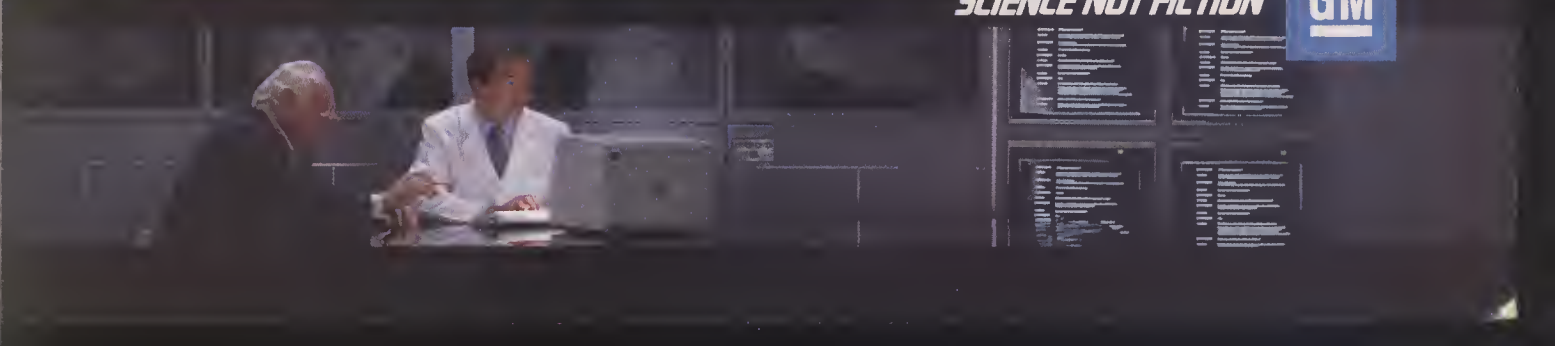
So, even when an engine expert retires from GM, his mind can still work for you. His lifetime of experience can go into a computer. The computer can then dispense this invaluable knowledge not only to GM engineers, but to your mechanic, too. That way, he'll be able to use this computer to help him service your car.

With artificial intelligence, a lifetime of experience can now last a hundred lifetimes. Because at GM, our quest for knowledge never tires.

Or retires.

**THE GM ODYSSEY:
SCIENCE NOT FICTION**

GM



beverages; and middle-sized biotech companies that can use Engenics' expertise to develop innovative bioprocessing techniques.

One client in the first category is Eastman Kodak's Bio-Products Division (Rochester, N. Y.), which established a \$2 million joint venture with Engenics last July to develop and commercialize microbial strains that will make biochemicals useful in the food industry. "We are looking for market opportunities in nutrition and food additives," says Jose Coronas, VP of the division. Engenics' experience will complement Kodak's skills in fermentation, separation, and purification.

Engenics also hopes to attract mid-level biotechnology customers through its research on innovative bioprocesses, which could be used for product manufacturing. For instance, the company has developed a new separation technology using affinity biopolymers—large molecules that are able to bind with specific materials. The resulting combination can then be more easily extracted. Potential applications include the removal of tumor-nurturing amino acids from blood, and removal of heavy metals from industrial-waste streams. Engenics has also engineered a process to convert the waste sugar lactose into lactic acid, a raw material in a broad range of

organic syntheses.

The bioprocess market is now worth about \$100 million, according to Stelios Papadopoulos, vice-president of biotechnology at Drexel, Burnham, Lambert (New York), who also points out that at least two of Engenics' competitors—BioResponse (Hayward, Cal.) and Damon BioTech (Boston)—have shifted their focus from contract research to production. Richardson does not rule out a similar evolution for his company. "Should the need for contract bioprocess development diminish," he says, "Engenics could eventually be producing its own specialty chemicals." □

—Ricki Lewis

SCIENTIFIC SYSTEMS SERVICES:

DIVERSIFYING INTO SYSTEMS INTEGRATION

Scientific Systems Services, a computer systems integrator based in Melbourne, Fla., found itself sitting pretty, at least for a while, after the Three Mile Island nuclear power plant malfunctioned in 1979. Founded in 1966, Triple S, as the company is known, specialized in the installation and servicing of equipment that monitored critical power flows and safety systems in process-control industries.

Prior to 1979, the company derived one-third of its revenues from electric utilities, and the remainder from the petroleum-refining, steel, and chemical industries. In the aftermath of Three Mile Island, revenues shot up from \$5 million in 1980 to \$24 million in 1984, largely in response to utilities' renewed demand for monitoring systems.

"We were a beneficiary of the changing regulatory environment," says Vincent Lamb, president of Triple S. "But high interest rates and fuel prices cut into utility profits; utilities then cut back on capital spending at the same time as heightened consumer concern contributed to a decrease in the commissioning of new plants." In other words, the company had become overly dependent on a faltering industry.

Over the past few years, Lamb has moved to correct the imbalance in his company's customer base by seeking out new markets that would build on his firm's experience in systems integration. "Our plan has been to diversify not only beyond the utility world, but outside the process-con-

trol sector as well," says Lamb. In particular, Triple S has gone after business in automotive, aerospace, consumer products, and other manufacturing industries; at this point, the company's utility business is back to where it was before Three Mile Island.

Triple S has won contracts both to automate car manufacturing at General Motors' \$400 million Buick City plant and to provide computerized quality control and production-monitoring systems for General Electric's lightbulb-manufacturing plants. The \$8 million Buick City job turned out to be unprofitable for Scientific Systems. "Our costs exceeded our estimates" on the fixed-price contract, says Lamb, "but this job was good in terms of getting other business."

Following the Buick City contract, Triple S won \$11 million worth of work at a variety of GM plants and from the giant automaker's Electronic Data Systems subsidiary; the systems that Triple S is providing in these projects will enable foremen to monitor production lines and spot defects early.

In spite of these efforts, the company may not face smooth sailing in its attempts to diversify. "Many of their present and potential customers in basic industries are cutting back on ambitious factory automation plans," says Robert Anastasi, an analyst with the Robinson-Humphrey brokerage in Atlanta. In addition, the uncertainty of GM's future relationship with Electronic Data Systems could undermine the latter's patronage of Triple S. Moreover, the

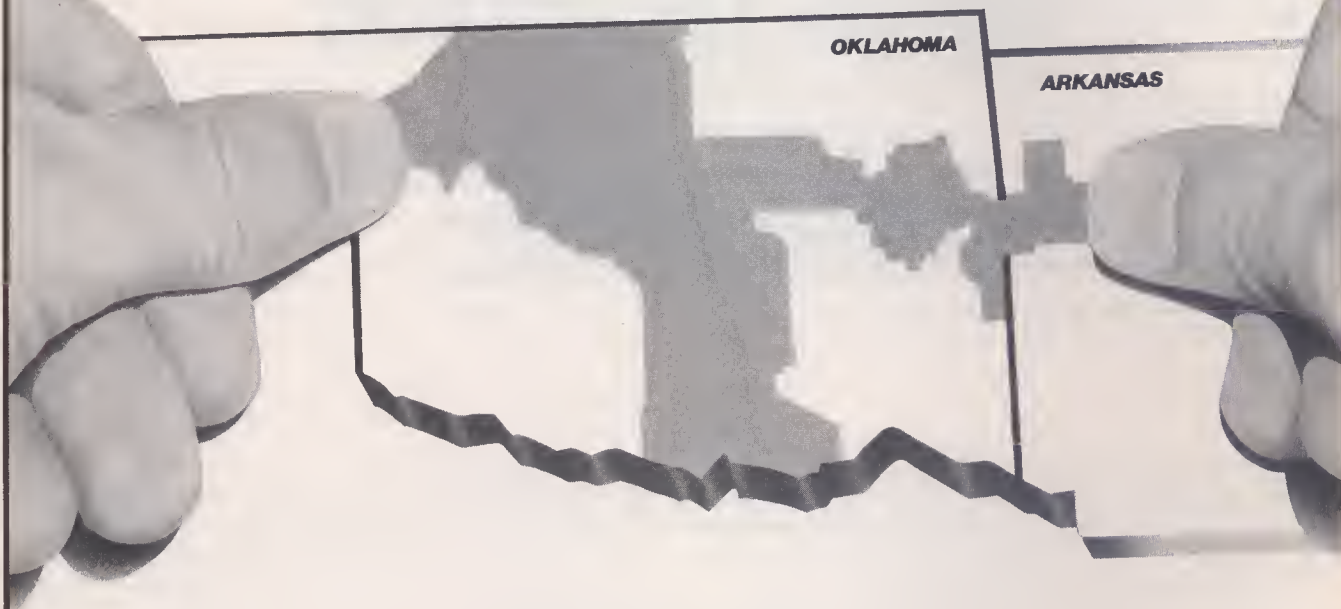


Scientific Systems Services has diversified its customer base under president Vincent Lamb.

company posted a \$4.5 million revenue loss in 1985 as a result of an out-of-court settlement with Northern States Power, which sued Triple S for defaulting on a contract.

However, says Anastasi, "the company has recovered from the suit and, by trimming its workforce after the loss in earnings, is at least in a leaner position to proceed with its diversification plans." Philip Leigh, a securities analyst with Williams Securities Group (Tampa), agrees that reduced overhead and a better customer balance will help Scientific Systems. "The company is now more profitable," he says. "And although they are not yet out of the woods, I think they've turned the corner." □ —Tim Smart

Profit knows no boundaries in the 51st state.



It's the state that offers endless profit potential: the OG&E electric service area in Oklahoma and Western Arkansas. It would be the ideal location for your company.

A highly-motivated work force, nationally-acclaimed Vo-Tech educational system, pro-business tax policies and below-average land costs are just the beginning.

The "51st State" also offers: millions of square feet of available industrial space; a central location for economical shipping; safe, clean communities with room for families to play and grow; and abundant, low-cost OG&E electricity.

Don't put boundaries on your

business — discover the "51st State." Ask OG&E's Economic Development Department for detailed information on available facilities, financing, education and training. Use the coupon or call Jack Rector, Manager of Economic Development at (405) 272-3460.

PROVIDING REAL OPPORTUNITY FOR INDUSTRY TODAY

OKLAHOMA GAS AND ELECTRIC COMPANY

Jack Rector, Manager of Economic Development, Dept. HI
P.O. Box 321, Oklahoma City, Oklahoma 73101
Or Call (405) 272-3460

Yes! I want more information on how to profit from the "51st State" — Oklahoma and Western Arkansas.

Name _____ Title _____

Company _____

Address _____

City _____ State _____ Zip _____

Telephone _____

Inquiries will be kept STRICTLY CONFIDENTIAL.

ARTIFICIAL INTELLIGENCE GOES TO WORK

***From financial planning to aerospace,
tools such as expert systems
are starting to make their mark***

BY DWIGHT B. DAVIS

After years of development, applications making use of artificial intelligence (AI) techniques are finally reaching the desks of everyday computer users—and not a moment too soon. Having heard about AI's potential for years but seen few hard results, would-be customers in the business community were beginning to grow skeptical. Meanwhile, the area in which vendors had largely focused their early marketing efforts—research and development—was becoming saturated.

AI is a broad-based technology that encompasses work in fields such as natural-language processing, vision systems, and speech recognition and synthesis. But most of its commercial impact so far is due to “expert systems”—programs that represent in software form the knowledge of human experts in different fields. Most commonly, they are based on “if/then” rules, which in conjunction with facts about a particular subject can logically progress through a given problem to arrive at an appropriate solution.

Expert systems come in all sizes and can be custom-built by vendors, consultants, or in-house researchers, as well as bought off-the-shelf in generic packages. One of their main attractions is that they often permit the actual users to have a say in the way the systems operate. Such input is usually necessary, in fact, because expert systems are meant to mimic the knowledge and procedures of real people. As a result, application programs tend to be much closer to users' actual needs than traditional software programs written in isolation by data processing professionals.

Expert systems offer other benefits as well. Once the expertise is computerized, it can be accessed by many users at a time—a practice not feasible with human experts. Since virtually all expert systems permit users to query them about the reasoning behind their decisions, they can be used to train novices. Finally, the computerized knowledge stays with the organization that owns the system, even if the human expert

leaves, and thus becomes a permanent asset.

To counter the growing perception that AI is little more than an obscure field of interest to a fringe element of researchers but of little practical use, vendors last year began loudly promoting the applications that were beginning to materialize. Nowhere was this push more evident than at the industry's major show, the American Association for Artificial Intelligence (AAAI) conference and exhibition, held in Philadelphia last August. In booth after booth, vendors gave demonstrations, showed videotapes, and presented user testimonials of productive AI installations. The demonstrated applications—virtually all based on expert systems—ranged from a diagnostic system that assists a computer vendor's field service engineers, to a knowledge base that aids scientists investigating metal corrosion, to a program with expertise in VLSI design.

As the following case studies illustrate, AI is increasingly being employed for practical tasks, and is permitting new uses of computers that simply weren't possible before the technology started to be commercialized. In one of the examples, an off-the-shelf expert system makes financial-plan recommendations and generates reports based on its knowledge of subjects such as tax law and interest rates, as well as each client's stated objectives. In another case, an internally developed expert system takes descriptive information about parts designed for aircraft and produces process plans that describe how best to manufacture the parts. Because these applications and the others described must apply a high level of expertise to a wide range of situations, they require capabilities that surpass those of static and inflexible conventional software.

Still, the systems profiled are not total solutions that can be left to operate autonomously. In all cases, they are treated as tools—very powerful tools—that assist people rather than replace them.

CREDIT WHERE CREDIT IS DUE

The credit card business has always been competitive, with each major player working hard to provide its own distinctive features and services. For American Express, one such offering has been the absence of a preset spending limit.

While popular with consumers, this feature can be an administrative nightmare. Relative to bank cards, with their set credit limits that can be easily checked to determine if new charges are too high, the American Express analysis is quite complex. It requires a sophisticated network of 300 authorizers, who may have to access as many as 13 different databases before deciding whether or not to approve individual charges. But as of this year, the authorizers are being assisted in their task by a custom-built expert system.

In the vast majority of cases when a merchant seeks approval for a cardholder's charge, it is granted automatically, says Bob Flast, vice-president of technology at American Express Travel Related Services Co. (New York). As transactions arrive from hundreds of thousands of merchants, they are first analyzed by statistical models on an IBM 3033 mainframe based in Phoenix. The statistical models essentially look for charges that fall outside the typical credit patterns established for different types of cardholders.

When the models find such aberrations, they cannot automatically approve the transaction. Instead, a "maybe" recommendation is transmitted to a human authorizer located at one of four sites around the United States. While the merchant and the cardholder wait, the authorizer searches for any clues to determine whether the person using the card is the true cardholder and, if so, whether that person is likely to pay the charge.

In an earlier position, Flast was in charge of the continuing development of the company's real-time authorization system, and was searching for further ways to streamline the job through increased automation. Recognizing that much of what the authorizers did was inherently rule-based, he acquired an inexpensive expert system toolkit to build a simple demonstration model. Management was impressed, and in the middle of 1985, Flast got approval to begin development of a full-scale expert system with the help of an appropriate vendor.

Of 14 companies invited to bid on the project, five submitted proposals. Flast and an ad hoc group of American Express colleagues chose Inference (Los Angeles) and its expert system development product ART (Automated Reasoning Tool) for the job. The current literature suggested that ART was a powerful tool and, more important, "Inference was the least risk-averse of all the competitors," says Flast. "They were willing to commit to a completed project, as opposed to simply a prototype, and were willing to commit to performance guarantees in the delivered code." Performance was to be measured by the ac-



BILL BALLEBERG

Flast and Miller expect that American Express's authorization assistant will improve decisionmaking and boost productivity.

curacy of the advice given by the system, and by the speed of its responses.

To meet the first goal of the project—development of a stand-alone prototype by April '86—Inference personnel examined hundreds of cases and their resolutions, and extensively interviewed authorizers at the American Express authorization site in Fort Lauderdale, Fla., to determine the underlying rules by which they operated. In particular, the Inference "knowledge engineers" worked with Laurel Miller, manager of the credit authorization operation at the site.

To determine the rules Miller and the other authorizers employed, the Inference personnel queried them about the steps they went through to resolve actual cases. But such rules are not necessarily hard and fast, and different authorizers might treat the same case somewhat differently. "We had to arrive at a standard way to resolve each case, and that was determined through some give and take within forums," notes Miller. "It was a very time-consuming process."

Gradually, through a building-block approach of adding new rules, checking their operation, and tuning them appropriately, the system began to take shape. In April, Inference demonstrated a stand-alone prototype on schedule, and American Express decided to proceed with the project's pilot phase. Within five months, Inference was to extend and tune the system's knowledge base, and connect it via telecommunications facilities to the Phoenix mainframe. In addition, American Express had to provide automatic access to the databases normally searched by authorizers as they performed their jobs. These databases, maintained by a separate division within American Express,

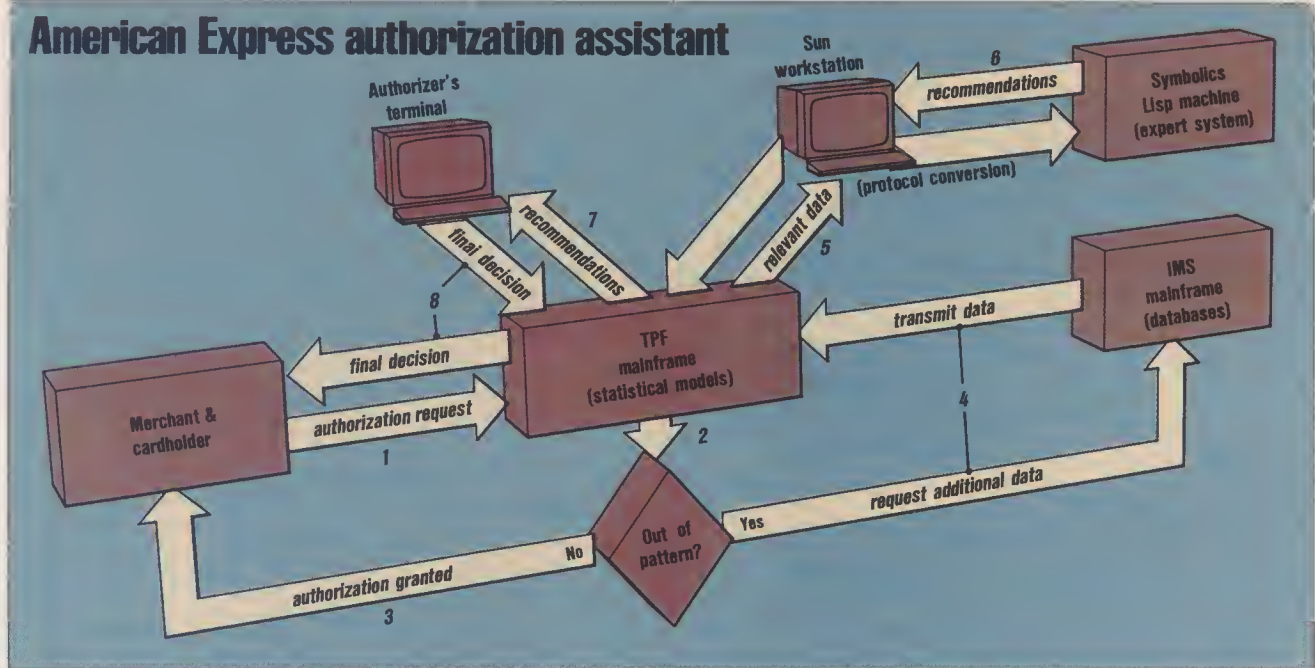
ARTIFICIAL

"The ability to reduce fraud and unpaid charges by even a fraction of a percent can have enormous economic consequences."

—Flast

INTELLIGENCE

American Express authorization assistant



When a merchant requests authorization to approve an American Express cardholder's charge (1), the request is first fielded by an IBM mainframe—running the TPF operating system—that determines if the transaction is a departure from the cardholder's normal charging pattern (2). If not, authorization is automatically granted (3); if so, the TPF computer requests and receives additional data on the cardholder (4) from a second mainframe running the IMS operating system. These new data, along with the original data, are sent to the Symbolics-based expert system through a Sun workstation (5), which converts the transmission from SNA to Ethernet communications proto-

cols. Once the expert system has applied its authorization rules to analyze the data, it passes its recommendations back to the TPF mainframe (6), which sends them to an authorizer's terminal (7). The authorizer considers the recommendations in making a final decision, which is then transmitted back to the merchant via the TPF computer (8). This entire process must take no longer than a few minutes, while the merchant and cardholder wait. To expedite the process in the future, the expert system will be linked directly to the authorizers' terminals, bypassing the protocol conversion step into the TPF mainframe.

reside on IBM computers running the IMS operating system instead of the TPF environment employed by the Phoenix mainframe. To complicate matters, the expert system itself had been developed under the Lisp-based ART toolkit running on a special-purpose Symbolics 3645 computer.

The Symbolics machine runs Ethernet local-area network protocols, and the IBM mainframes operate under the Systems Networking Architecture (SNA) environment. The best way available at the time to connect the two networking environments was to use a Sun Microsystems workstation as a protocol convertor. Although the system is still operating under this architecture, American Express ultimately expects to get a single-vendor solution for running the expert system and connecting it to the mainframes. Already, three vendors—Symbolics, Sun, and Texas Instruments—are working to offer computers that can run the ART system and SNA communications protocols. This would eliminate the need to have a separate machine (the Sun workstation, in this case) convert data between the Ethernet and SNA environments. In addition, says Flast, American Express is considering the possibility of supporting ART on its mainframes.

Building the so-called intersystem bridges has proved to be the most difficult aspect of the project, much more so than the building of the expert system itself, according to Flast. And the hardest task hasn't been the connection between the TPF operating system and the Symbolics computer running ART, but that between the two IBM operating systems.

Despite various setbacks, the work on a direct link between the TPF mainframe and the IMS systems has started to show results. This architecture began fielding actual referrals in mid-January. Based on the system's performance to date,

American Express expects that it should improve the productivity of the authorizers by 20–30%. Even more important, notes Flast, is the system's potential to apply its knowledge base to reduce fraud and cut down on charges that go unpaid. American Express won't release information about the losses it suffers from fraud and nonpayment, but Flast points out that public records of the bank card industry indicate that associated losses are measured in the hundreds of millions of dollars. "The ability to reduce these problems by even a fraction of a percent can have enormous economic consequences," he says.

American Express expects to begin the rollout of the system—following a final validation test—throughout its U.S. operations by midyear. Meanwhile, the current system, consisting of about 800 rules, continues to impress its human counterparts with its speed and the quality of its advice. But Flast points out that the system is not meant to operate autonomously. Rather, it will serve as a tool that eases the burden on the human authorizers. Also, he says, the company doesn't view the system as a replacement for existing authorization staff. Instead, it will simply allow American Express to keep pace with its growing number of transactions without hiring a large number of new authorizers.

How does the human expert behind the system assess the automation effort? "I am more encouraged every time I watch an authorizer sit down and work with the system," says Miller. She acknowledges that it will require constant modification and tuning as more experience is gained in automating the authorization process. "But as I look at transactions," she says, "I know that if things I want in the system are not there, I can easily have them put in."

SPEEDING UP FINANCIAL PLANNING

Developing a financial plan for an individual is a complicated and time-consuming task. The planner must balance each client's unique financial situation and long-term goals with wide-ranging and interrelated factors such as taxes, prior investments, insurance coverage, and real estate holdings. "It's such a complex field that we tend to operate a lot on intuition and rules of thumb," says Harold Evensky, a certified financial planner and president of Evensky & Brown (Miami). "Otherwise, it would take forever to create a plan."

To help manage this process, Evensky & Brown in early 1986 became one of the first buyers of PlanPower, an expert system sold by Applied Expert Systems (APEX) of Cambridge, Mass. Designed to assist in the creation of financial plans, the system is sold bundled with the Xerox 1186 Lisp machine for about \$45,000. Using PlanPower, the firm's staff can produce a plan in about a quarter of the time previously required, says Evensky; a moderately complex plan that once took about 50 hours of computer time to produce can now be generated in 10 or 15.

PlanPower's knowledge base contains information on such things as interest rates, expected inflation rates, and tax laws, as well as standard investment strategies to realize given objectives. Supplied with enough data, the system can even produce an entire report in everyday English, complete with charts and graphs illustrating the plan's major aspects. "If you put in the data for a simple plan and just pushed a button," says Evensky, "you would get out an 'A'-quality plan. If you did a very complex plan, it might come out as a 'C+', which would still be acceptable." Nonetheless, Evensky prefers that PlanPower be used only as a tool, backed up by the expertise of his firm's own qualified planners. "It's just an assistant," he says, "but a phenomenal assistant."

Of all the system's capabilities, Evensky rates its ability to do "what if?" projections among the most important. If a client asks for advice about, say, whether to buy or lease a car, the system can quickly model and compare the five-year impact of each option.

Another key benefit of the system, says Evensky, is that all data reside in the same database. The conventional planning software the company previously used didn't allow the integration of different databases—for instance, those that contained mortgage algorithms and those that contained stock investment information. If a change was made in one area, it was difficult to track its effect in others.

With PlanPower, all the information is combined, and the stand-alone system can even make connections sometimes overlooked by human planners. High-income clients, for example, are usually advised to in-

vest in tax-free money markets, but in one instance, PlanPower recommended a taxable money market instead. "That didn't seem to make any sense," says Evensky. But by querying the system about its recommendations, it was noted that the client had been advised to borrow money for some other purpose; under the tax laws, a person can't deduct the interest from a tax-free account while at the same time borrowing money, so there was no advantage to investing in the tax-free money market. "I consider myself a very senior planner, and it's something I would have missed," Evensky admits.

A constant problem with such an expert system in this field is keeping its knowledge base up to date as financial realities change. Of late, the major problem in this regard has been the massive changes in the tax code. Updates from the vendor have been "adequate, but frustrating to implement," says Evensky, largely because of the magnitude of the changes. He has also found it difficult to modify the system's assumptions to better fit his firm's perspectives. In theory, each user can change the system's knowledge base—for example, to weight investment options differently—but "I frequently have to trick the system to do what I want it to do," he says. APEX made the system fairly rigid, according to Evensky, because the vendor thought that inexperienced users might inadvertently corrupt the system's advice if it were too easy to change the knowledge base. But a new version of PlanPower will reportedly give planners more control over setting the system's parameters.

ARTIFICIAL

"If you put in the data for a simple plan and push a button, you get out an 'A'-quality financial plan."
—Evensky

INTELLIGENCE

Financial planner Evensky says PlanPower helps run complex "what if?" analyses.



CHUCK MASON

HOW TO BUILD A FIGHTER PLANE

In early 1983, Ken Lindsay and Bob Joy of Northrop Aircraft Division (Hawthorne, Cal.) were assigned to study and upgrade the firm's process planning operations. The project given to the two men—both systems technical specialists within the Production Systems Development Group—was of vital importance to the division, whose primary business is the design and manufacture of military aircraft such as the F/A-18. To build such a plane, it's necessary to fabricate more than 10,000 individual parts, each requiring its own process plan to describe the steps and the method of its manufacture. A typical process plan takes a human planner 8 to 12 hours to complete; if errors in the plan aren't discovered until it reaches the shop floor, the required revisions may result in tool reworking, production delays, and the scrapping of parts.

Shortly after Lindsay and Joy began their investigation,

they attended an industry association meeting at which the potential of artificial intelligence was discussed. "We came back convinced that AI was the way to address our process planning objectives," Lindsay recalls. Their first attempt to convince management of AI's usefulness—a presentation about the technology by an AI expert—was unsuccessful, says Lindsay, because the expert failed to "bring home how the technology could directly affect the cost, quality, and scheduling of producing aircraft." But things changed shortly thereafter, when Lindsay modified a sample program he found in a computer magazine to build a 22-rule expert system on his Apple II computer that produced simple process plans for sheet metal parts. "Because the program performed a recognized function and was capable of explaining its reasoning," he says, "it conveyed the potential of the technology to management." Lindsay and Joy thus got the go-ahead to develop a full-scale expert system.

Part of the reason that the developers had first been at-

REPRESENTATIVE ARTIFICIAL INTELLIGENCE PRODUCTS

PACKAGED EXPERT SYSTEMS

Company	Products
Applied Expert Systems Five Cambridge Center Cambridge, MA 02142 (617) 492-7322	PlanPower, designed to assist financial planners in the development of strategies for their clients and in the generation of printed plans. Runs on Xerox 1186 Lisp machines.
Boole & Babbage 510 Oakmead Pkwy. Sunnyvale, CA 94086 (408) 735-9550	DASD Advisor, a performance management tool for diagnosing mainframe computer performance problems and recommending corrective action. Runs on IBM computers under the MVS operating system.
Factron EDA 269 Mt. Hermon Rd. Scotts Valley, CA 95066 (408) 438-2880	ESP/C, an IBM PC/AT-based system to assist in custom and semicustom integrated circuit design, layout, analysis, and verification.
International Systems Services Two Grand Central Tower New York, NY 10017 (212) 972-4400	ISS Three, a computer capacity management system providing work-load forecasts and modeling of alternative configurations. Comes in two modules, one running on IBM mainframes under MVS, the other on IBM PCs.
Palladian Software Four Cambridge Center Cambridge, MA 02142 (617) 661-7171	Financial Advisor, which helps Fortune 500 companies analyze the impact of business decisions; Operations Advisor, for aiding factory managers in making production decisions. Both run on Symbolics and Texas Instruments Lisp machines.
Perisoft 600 West Cummings Park Woburn, MA 01801 (617) 935-0095	More (for in-house use) and More/2 (for direct mail service bureaus)—two packages for ranking names on address lists for direct mail operations. Both run on IBM mainframes.
Transcomm Data Systems 1380 Old Freeport Rd. Pittsburgh, PA 15238 (412) 963-6770	Tolas Telestream, which works with the firm's Tolas order entry and financial management system, and helps field phoned-in customer orders. Runs on Digital Equipment MicroVAX computers.
Syntelligence 1000 Hamlin Ct. P.O. Box 3620 Sunnyvale, CA 94088 (408) 745-6666	Underwriting Advisor, which assists property and casualty insurance underwriters; Lending Advisor, to help commercial banks analyze the advisability of making corporate loans. Both run on Symbolics Lisp machines.

NATURAL-LANGUAGE PROCESSING

Artificial Intelligence 100 Fifth Ave. Waltham, MA 02254 (617) 890-8400	Intellect, designed for English queries of databases residing on IBM computers. Interfaces to a variety of database management systems, including DB2, and has a PC-based query module.
Frey Associates Chestnut Hill Rd. Amherst, NH 03031 (603) 472-5185	Themis, which runs on Digital Equipment VAX minicomputers under the VMS operating system. Interfaces to Datatrieve or Oracle database management systems.
Intelligent Business Systems 246 Church St. New Haven, CT 06510 (203) 785-0813	Easytalk, sold bundled with a Digital Equipment MicroVAX II computer and with database, accounting, word-processing, and communications software.
Natural Language 1786 Fifth St. Berkeley, CA 94710 (415) 841-3500	DataTalker, which interfaces with SQL-based database management systems such as Oracle and Ingres. Runs on Sun 3 workstations or Digital Equipment VAX computers.

EXPERT SYSTEM TOOLKITS/AI LANGUAGES

Aion 101 University Ave. Palo Alto, CA 94301 (415) 328-9595	Aion Development Systems (ADS) and Aion Execution Systems (AES), for IBM mainframes running MVS or VM and for IBM PCs. Applications developed on PCs can run on mainframes, and vice versa.
CAM Software Westpark Bldg. 750 North 200 West Provo, UT 84601 (801) 373-4080	DCLASS, a general-purpose decision tree program to assist in capturing experts' decision logic and knowledge.
Carnegie Group 650 Commerce Ct. Station Sq. Pittsburgh, PA 15219 (412) 642-6906	Knowledge Craft, a knowledge representation and problem-solving environment; Language Craft, a tool for constructing natural-language interfaces. Both run under Common Lisp on Symbolics and Texas Instruments Lisp machines and on VAX computers.
Expertech (U.S. office) 650 Bair Island Rd. Suite 204 Redwood City, CA 94603 (415) 367-6293	Xi Plus, which runs on IBM PCs and compatibles and offers an English interface for creating knowledge bases and applications.

tracted to AI was their decision to pursue a "generative" approach (in which a specific plan is created from scratch for each new part) rather than the method the company was using at the time—the "variant" approach (in which previously created plans are used as a basis for producing new ones). The latter required constant maintenance of the standard plan database, from which new plan variations were derived. Also, the knowledge that went into the creation of the standard plans was not explicit in the stored plans themselves. Thus, if the people who produced the original plans left the company, the reasoning that went into the plans' creation left also.

With the generative approach, the knowledge of how to manufacture parts, based on each part's description and on the available shop-floor machinery, is applied repetitively. If the process planning were done by people, this approach would be unwieldy; in effect, the planner would constantly have to reinvent the wheel. But if the knowledge of how to manufacture parts can be applied by a computer, the genera-

tive approach is much more attractive. It eliminates the need to maintain a standard plan database, and it establishes the knowledge of process planning as a permanent corporate resource. In addition, the knowledge base can be used as a training tool, explaining the logic it followed.

To develop a full-scale expert system for process planning, the Northrop team acquired a Xerox 1108 Lisp machine and the Knowledge Engineering Environment (KEE) development toolkit sold by Intellicorp. These products were chosen because the system was to be built not by computer scientists but by the people most familiar with the manufacturing and engineering environment. It was felt that the Xerox machine and KEE, which operated under the InterLisp language at the time, offered a "more forgiving" development environment than the other available Lisp machines and language variants.

(KEE has since been rewritten to operate with Common Lisp, which has become an accepted standard, and Northrop has acquired a second Xerox computer, an 1186, to assist in

Expertelligence

559 San Ysidro Rd.
Santa Barbara, CA 93108
(805) 969-7874

Expert Systems International

1700 Walnut St.
Philadelphia, PA 19103
(215) 735-8510

Franz

1141 Harbor Bay Pkwy.
Alameda, CA 94501
(415) 769-5656

Gold Hill Computers

163 Harvard St.
Cambridge, MA 02139
(617) 492-2071

Inference

5300 W. Century Blvd.
Los Angeles, CA 90045
(213) 417-7997

Intellicorp

1975 E. Camino Real West
Mountain View, CA 94040
(415) 965-5500

International Business Machines

1133 Westchester Ave.
White Plains, NY 10604
(914) 696-1900

Logicware (U.S. office)

70 Walnut St.
Wellesley, MA 02181
(617) 237-2254

Lucid

707 Laurel St.
Menlo Park, CA 94025
(415) 329-8700

ExperCommonLisp and ExperProlog II languages; ExperOPS5 and ExperFacts toolkits. Designed to run on Apple Macintosh and IBM PCs, as well as Sun, Apollo, and VAX computers.

VAX/VMS Prolog-2, an interpreter/compiler for VAX computers; Prolog-1, a subset of the Prolog-2 language for various other computers, including IBM PCs.

Extended Common Lisp, a superset of the standard; Franz Lisp Opus 43, the firm's own Lisp dialect. Both run on a variety of machines from micros to mainframes.

Golden Common Lisp (GCLisp) for 286- and 386-based PCs; GCLRun for delivering PC applications; Concurrent Common Lisp for use on Intel's iPSC; GCLisp Network to connect PCs to Symbolics Lisp machines; and 386 HummingBoard, a PC-based Lisp processing board.

Automated Reasoning Tool (ART), a development environment available in a Lisp version for Symbolics, LMI, Texas Instruments, Digital Equipment, and Sun computers, and in a C version for the IBM RT PC and for DEC VAX, Sun, and Apollo computers.

Knowledge Engineering Environment (KEE), a development environment in Lisp that runs on LMI, Symbolics, Texas Instruments, Xerox, and Sun computers; SimKit, a simulation package; KEEconnection, to link KEE knowledge systems to databases; IntelliScope, for database search and analysis.

Expert System Consultation Environment (ESCE) and Expert System Development Environment (ESDE) for mainframes running MVS or VM; Lisp/VM and VM/Prolog languages.

Twice, a Prolog-based development environment running on IBM mainframes, as well as DEC VAX, Sun, Apollo, Tektronix, and Pyramid computers; MProlog language.

Lucid Common Lisp—the standard Lisp dialect along with an embedded editor, a windowing facility, an object-oriented programming paradigm, and debugging utilities.

Prophecy Development

Two Park Plaza
Boston, MA 02116
(617) 451-3430

Quintus Computer Systems

2345 Yale St.
Palo Alto, CA 94306
(415) 494-3612

Teknowledge

1850 Embarcadero Rd.
P.O. Box 10119
Palo Alto, CA 94303
(415) 424-0500

SYMBOLIC PROCESSORS

Integrated Inference Machines

1468 Katella Ave.
Anaheim, CA 92804
(714) 978-6776

LISP Machine Inc. (LMI)

175 Cabot St.
Lowell, MA 01854
(617) 458-9100

Symbolics

Eleven Cambridge Center
Cambridge, MA 02142
(617) 259-3711

Texas Instruments

12501 Research Blvd.
Austin, TX 78769
(512) 250-7111

Xerox

Xerox Center
101 Continental Blvd.
El Segundo, CA 90245
(213) 536-7000

Contessa (Contextual Expert Systems), a family of development tools running on Symbolics and Texas Instruments computers; Profit Tool, an application to help sales and marketing staff define markets, identify prospects, and close sales.

Quintus Prolog—the Prolog language along with a development system running on the IBM RT PC and DEC VAX, Sun, Xerox, and Apollo computers; Quintus Run-Time System, for applications delivery.

S.1, a C-based development tool running on the IBM RT PC, as well as on IBM mainframe, DEC VAX, and HP 9000/300 computers, and on Unix-based workstations; M.1, a C-based development tool for IBM PCs.

SM4500, due out this month following the completion of its beta testing. Runs a superset of Common Lisp; includes an 80286 I/O processor that can simultaneously run MS-DOS programs.

LMI Lambda series, including multiuser models; software supported includes ZetaLisp-Plus, LM-Prolog, ObjectLisp, Common Lisp, and the Flavors and ZMACS editors.

Symbolics 3600 series, including the 3610AE applications-delivery processor; software supported includes the Genera development environment (Common Lisp, Flavors), Prolog, Ada, Fortran, and Pascal languages, and the MACSYMA for solving mathematical problems.

TI Explorer system running Common Lisp and Flavors, with options including a natural-language toolkit, a graphics development package, knowledge engineering tools, and a Prolog toolkit; also sells Personal Consultant, a development environment running on MS-DOS-compatible PCs.

Xerox 1100 series, working under Xerox Network System (XNS) protocols, and Common Lisp and InterLisp-D; CommonLoops object-oriented programming; Trillium, an application package for creating better man/machine interfaces.



Northrop's Joy (left) and Lindsay aim to generate process plans in minutes, not hours.

the continuing program development and deployment.)

Following a fairly lengthy ordering and delivery process, the Xerox/KEE system was up and running at Northrop in February of 1985. Two months later, the development team demonstrated its first prototype. Much of the remainder of 1985 was spent expanding the knowledge base and evaluating ways to transmit the system's advice to process planners. The solution, still in place, was to use a Xerox disk file server on an Ethernet local-area network to carry the information between the Lisp machine and IBM PCs on the planners' desks.

Northrop used a decision tree program called DCLASS (developed at Brigham Young University and marketed by CAM Software of Provo, Utah) to develop a PC-based program that elicits the needed part description information from users. The data then travel over the network to the expert system, which applies its knowledge base to the problem and produces a plan. Knowledge is represented in KEE in frames, or "units," which contain everything from descriptions of the new parts and shop-floor equipment, to the logic employed by the system's rules.

Given the part's description list, the system uses both "forward" (or "data-directed") reasoning and "back-chaining" (or "goal-driven") reasoning to determine the necessary fabrication, processing, and inspection steps required to manufacture the part. The system currently holds more than 500 rules defining how to manufacture parts at Northrop. To avoid erroneous planning decisions, the system determines whether a current decision will conflict with previous decisions, or

with other relevant constraints.

For example, the data-driven reasoning mechanism might make a preliminary determination that a sheet metal part being planned could be trimmed with a hand-held router guided by a template of the part. This method involves very little tooling but requires more operator skill and would not be appropriate for large production runs. But routing may represent just one of several valid manufacturing options, and it cannot be assumed that the system has logically eliminated other, possibly more efficient, methods of trimming the part. Before asserting that the part should be routed, therefore, the system determines whether or not a different method of trimming, such as blanking the part on a punch press, is appropriate. Only after such analysis does the system indicate the trimming method.

The expert system now routinely converts descriptions of certain types of parts into process plans in about five minutes (in contrast to the several hours human planners require). The system is scheduled to be installed for production use by midyear and fully integrated into the division's day-to-day operations before year's end. This eventual installation, however, raised a critical re-

quirement: the division needed a way to verify the accuracy of the generated plans before committing manufacturing facilities to carry them out. The solution to this problem has been found in a simulation product called SimKit, which Intellicorp devised in part through consultations with the Northrop developers.

Using Simkit, Northrop has been able to model the parts, the conveyors, and the machines actually operating in a manufacturing cell on the shop floor. "We are then able to take the process plans produced by the expert system and run them on the shop model to verify their accuracy," says Joy. If a part's manufacturing requirements don't match the available shop-floor resources, that fact can be determined at the simulation stage, thus eliminating last-minute surprises.

A future use of the SimKit package—which is running on a Symbolics 3670 Lisp machine—will help the company schedule its manufacturing operations as efficiently as possible. Through this project, being developed by the Northrop Research and Technology Center, the company plans to link the SimKit model to the actual shop floor. That way, the model will be able to replicate in real time the events happening on the floor and to serve as an input device for controlling the manufacturing processes. A dynamic scheduling program will then be attached to the model and will reconfigure it to suit the workload. "Control of the model by the scheduler will result in an identical control of the shop floor," Joy says, "so we will be using the SimKit simulation as a conduit for implementing the scheduler's control."

ARTIFICIAL

"The program performed a recognized function, so it conveyed AI's potential to management."

—Lindsay

INTELLIGENCE

Other future developments may occur on the front end of the process planning expert system. For example, Northrop is looking into integrating the system with its computer-aided design and drafting systems so that a person will no longer have to look at each part drawing and manually input description data. Perhaps the most important aspect of the AI-based planning system and the other expert systems being developed at Northrop is that the people using these applications need not be experts in the functions being performed, according to Lindsay and Joy. With expert systems such as the process planning system, Northrop hopes to leverage the abilities of "general practitioners" and to allow the consolidated, or simultaneous, application of a range of specialized knowledge.

This approach would eliminate problems that can occur if the expertise is applied in a step-by-step sequential pattern, says Lindsay. In many engineering environments, for example, a part design is generated and then sent on to manufacturing engineers, who determine the feasibility and expense of producing the part. If the expertise of the manufacturing engineers could be applied during the initial design process, parts could be designed more intelligently, and the costly setbacks that occur when a design proves difficult or impractical to manufacture would be avoided.

KEEPING RELAY CUSTOMERS HAPPY

One of the main products of Westinghouse's Relay and Telecommunications division—relay protection systems—can be configured in a great many ways to meet a wide range of functional requirements. Designing them used to be a tedious and protracted process. But then the division, based in Coral Springs, Fla., turned to the company's Productivity and Quality Center (Pittsburgh) for

ARTIFICIAL

**"Before CORA,
there was no
central repository
of knowledge
about each
product
variation."**

—Sieger

INTELLIGENCE

assistance. The result was CORA (Customer Order Relaying Assistant), an expert system that draws on a huge library of relay component styles to help engineers build diverse protection system configurations.

Relay protection systems are usually ordered by power companies, which use them to protect generators and transformers from power surges, as well as to identify and correct problems such as downed power lines. The seven- to eight-foot-high units contain mixtures of relays that range in price from hundreds to thousands of dollars, and cover the technological span from electromechanical units to computer-like printed circuit boards. The types of relays employed depends on such variables as the voltage ratings and length of the monitored lines and the climate in which they operate. "Typically the power companies like to have things their way," says Ed Sieger, senior engineer and chief developer of the expert system. "So we use CORA to make sure that the ordered system will work the way they want it to, and if it won't, to help us modify the system appropriately."

In early 1983, when the designers at the Productivity and Quality Center started work on CORA, they used a development environment called SRL that had been created at Carnegie-Mellon University (it later evolved into the Knowledge Craft toolkit sold by the Carnegie Group). SRL was written in the Franz Lisp dialect, and the early development work was done in that language on a Digital Equipment VAX-11/780 superminicomputer. Later, when Common Lisp was established as the standard Lisp dialect, Sieger converted the system development to run under a Common Lisp compiler that Digital Equipment offered for the VAX. He also acquired Gold Hill Computers' GCLisp, a subset of Common Lisp that runs on IBM Personal Computers, to aid in the development process and to run CORA on the user's desk.

Sieger chose to use the more familiar VAX for the continuing system development, although he says GCLisp running on IBM PC/ATs could also have been used. In fact, he sometimes used the AT systems to test portions of the program because, surprisingly, they ran the program faster than the VAX. The operational version of CORA can now run either on the VAX or on PC/ATs, which serve as the program's delivery vehicles.

CORA is a frame-based expert system, as distinct from the more common rule-based paradigm. A frame is dedicated to each object that the system needs to know about—say, a particular component—and contains detailed information on

Sieger of Westinghouse says the CORA expert system reduces the time it takes to configure relay systems and ensures that they will work properly.



DAVE VANDEVEER

each object's attributes. Frames can be connected in a hierarchy so that lower-level frames "inherit" the attributes of their parent frames and so that relationships can be defined—for example, how two parts work together. CORA contains knowledge of almost 600 components, divided into more than 3000 frames. The total program is fairly large, consisting of about 10,000 lines of code.

In operation, a customer order engineer enters the customer's specifications for a series of relay devices into the CORA system one item at a time, responding to system prompts and directing the system as necessary. CORA then searches the on-line library of existing component variations; in about 15 seconds, it comes up with one or more "style numbers" of relays that meet the specifications. Before CORA, "there was no central repository of knowledge about each style variation," says Sieger, "and it would take an engineer a day or two to leaf through all the different drawings and fact sheets to come up with exactly the style number needed."

Once the engineer has used CORA to determine the style numbers for all the required devices, it can run a verification procedure to determine if the total system will function as specified. If so, the engineer instructs it to produce an "engineering bill" of materials. CORA is interfaced to a Burroughs mainframe that contains a bill-of-materials file, and together the two systems produce a "manufacturing bill" that contains "everything down to the nuts, bolts, and screws that the shop is going to need," says Sieger. Later, if revisions are needed, CORA is used to implement and track them.

In January, CORA began serving the Relay and Telecommunications division's customer order engineers, and was scheduled for introduction to the division's marketing operations the following month. Sieger notes that the marketing staff could use CORA's verification mode to ensure that they haven't overlooked necessary components when bidding on a customer's system—a function that may be of even greater benefit than the system's ability to locate the proper style numbers. "With CORA," he says, "we'll improve the quality and profitability of our quotations."

DIAGNOSING SICK ROBOTS

Automobile manufacturers are increasingly relying on robots to improve efficiency and cut costs. But when one of them fails, fixing it is no simple matter. Not only are robots highly sophisticated pieces of equipment, but they come in a wide variety of designs and are constantly evolving.

Ford Motor realized that its maintenance engineers were being overwhelmed—the company has more than 3000 robots installed today, and expects to have 5000–7000 by 1990—so it turned to its Robotics and Automation Applications Consulting Center (Dearborn, Mich.) for help. The solution, based on expert systems and graphics technology, is being promoted by Ford as a generic diagnostic and repair system that all its robot suppliers can adapt to their own machines.

A key objective of the diagnostic program's developers was to demonstrate that creating such a system need not be expensive or time-consuming. The Robotics Center spent only \$5000 developing its prototype, which was built by two people in just six weeks. "Admittedly, the two people were very

ARTIFICIAL

"The rule base covers about 20% of the rules, but that's sufficient for 60–80% of the problems people run into."
—Whitney

INTELLIGENCE

good," says Morgan M. Whitney, the center's director, "but neither had any previous AI development experience." One of the developers was a programmer with 30 years of experience, the other a "domain expert" in the operation and care of robots made by ASEA.

The developers worked with Personal Consultant—an expert system development toolkit sold by Texas Instruments—which they ran on a TI personal computer. The prototype system contained about 100 rules designed to take maintenance personnel, step by step, through the procedure of diagnosing and fixing an ASEA robot's problems. That rule base "probably covers about 20% of the rules that will ultimately have to be written," says Whitney, "but that's sufficient for 60–80% of the problems people typically run into."

To further assist in diagnoses, Texas Instruments' SDRAW graphics program was employed to create a color graphic representation of the robot's components. Produced with a program written by a 22-year-old graduate trainee, it works in synchronization with the menu-oriented expert system to lead operators to the problem area.

The expert system is already up and running on IBM personal computers at three

Ford's Whitney says the firm's robot diagnosis procedure shows that expert systems need not be costly to develop.

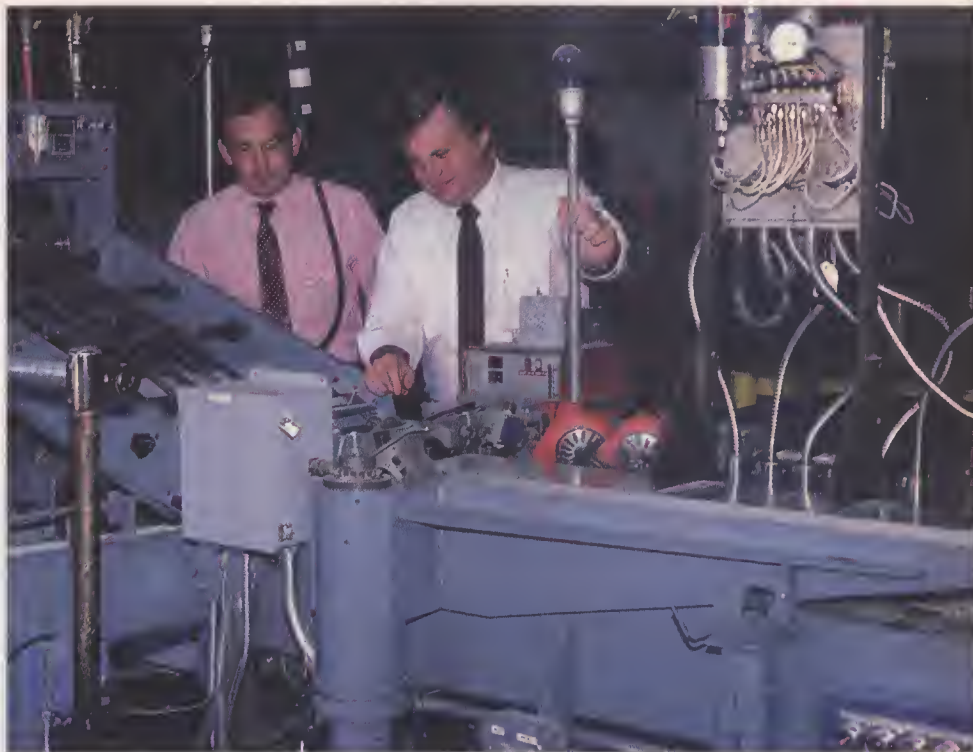


DENNIS COX

Ford plants and has generally been well accepted. There was some resistance at first, Whitney reports: "One guy said, 'You're really trying to replace us, aren't you?' But we hastened to point out that our aim was to give maintenance technicians a tool so they could be more productive." Once its role was understood, he says, "the people at the plants came after us for the system, and now they are quite pleased with it."

Will there be other versions of the system for other robots? "We can't possibly develop this for every piece of equipment that's out there," says Whitney. But the company is offering a floppy disk containing the system code and a videotape of the system in operation to any interested robot supplier. Ford hopes to encourage the vendors to create expert system diagnostic programs that would be easier to work with and to modify than printed repair manuals.

"The positive response we have gotten from the robot manufacturers continues to surprise us," Whitney says. Even though the company first publicized the program's availability almost one year ago, "we still get two or three phone calls a week from around the world, requesting information." He expects the first of the commercial diagnostic programs to appear by the second quarter of this year.



Selectronic's Ryan (left) and David Gill, superintendent of mailing services, prepare a mailing to prospects whose potential to respond has been ranked by the More/2 package.

PROSPECTING FOR DIRECT MAIL BUYERS.

Merchants sending catalogs, fund raisers making pitches, and magazines selling subscriptions all want to identify the hottest prospects for their direct mail campaigns. Experts in service bureaus that perform such marketing operations for their clients thus try to cull from their lists those people most likely to respond to any given mailing. An essential element is to study the results of previous mailings and attempt to identify variables such as age, zip code, and household income that seem to be associated with those who have responded positively in the past. At Selectronic Services (Chicago), an operating division of R. R. Donnelley & Sons, this list ranking is simplified through the use of the More/2 expert system sold by Persoft (Woburn, Mass.). Selectronic acquired an earlier version of the More software package over a year ago, and has upgraded it with the More/2 version, designed specifically for service bureaus.

The expert system, which runs on an IBM mainframe computer, has two basic sources for the data it needs to rank lists: back testing, which involves searching through the results of previous mailings, and limited test mailings to confirm the accuracy of the More/2 recommendations. "Only after that's come back the way we predicted are we ready to do a full roll-out mailing," says product manager Mark Ryan.

In addition, More/2 can automatically modify its underlying model if necessary—a feature that distinguishes the system from conventional analytic software. For example, an initial analysis to determine the best prospects for a specialty seafood catalog might be single women living in apartments who also have several other variables in common. More/2 would create a mailing model based on these key variables, weighting them appropriately, and the promotion would be conducted. The response rates would then be analyzed and used to

automatically change the model as needed. Later, if the catalog publisher started to add meat products to its line, the profile of the best responders might change. Through the primary mailings, and perhaps through additional test mailings, More/2 would pick up on this shift and adjust its model.

This capability relieves the staff of a great burden says Ryan. Before it obtained More/2, the company had to build its own statistically based models for mailings. And because creating such a model is very labor-intensive, there was a tendency to use it repeatedly over a long period, even well after it had outlived its usefulness. "Revalidating is not the easiest thing to do," says Ryan, "and one of the nice things about More is that it does that job automatically."

Initial results of More/2 directed mailings have been encouraging. The program has demonstrated that it can mail to just 50% of an existing list and—by targeting the people most likely to respond—achieve 70–80% of the responses obtained when the entire list is used. This allows the service bureau to operate more effectively, Ryan notes, "by sending smaller mailings repeatedly to the high-productivity pockets."

Since installing More/2, Selectronic has modified the system's rule base to better reflect the firm's procedures in different areas of the mailing business. "If certain variables happen to show up a lot, but you know from experience that they don't actually help in the response rate, you can weight their importance accordingly," Ryan explains. Thus, if the system's analysis causes it to construct a model in which a questionable variable is ranked high, the company experts can modify the model to better reflect the variable's true importance.

Through such system tuning, the firm hopes to achieve maximum performance. Meanwhile, competitors are also purchasing the Persoft software, and Ryan acknowledges that "any advantage we have through our early installation is a temporary one." Nevertheless, he adds, "the system is an important tool for us to have in our repertoire."

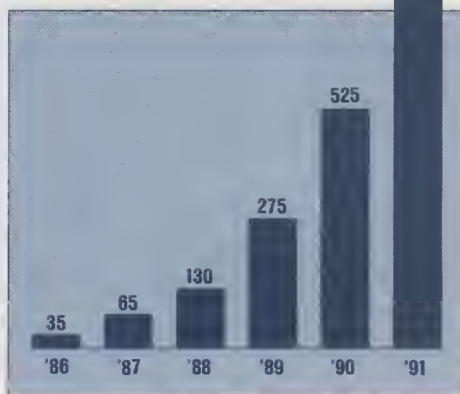
EXPERT SYSTEM VENDORS AIM FOR SIMPLER, LOWER-COST PACKAGES

Until recently, the market for expert systems—software that mimics human reasoning processes—consisted almost exclusively of specialized programming tools that allow users to develop their own applications. But now, a handful of vendors have developed off-the-shelf application software that saves companies the time and effort of building customized programs. Sales of such expert system software were \$35 million in 1986, compared to an \$84 million market for tools, according to AIM Publications (Natick, Mass.), which publishes the *Artificial Intelligence Markets* newsletter. AIM predicts the applications segment will account for nearly \$500 million in 1990, approximately equal to revenues from tools.

Most application programs sold are highly specialized. General Electric (Erie, Pa.), for example, offers a locomotive diagnosis system, and Crosfield Composition Systems (Elmsford, N.Y.) sells a system that lays out pages for daily newspaper publishers. But a few companies address broader areas. Palladian Software (Cambridge, Mass.) has developed expert systems that help a company make business and operational decisions. Syntelligence (Sunnyvale, Cal.) has targeted the insurance and banking industries with programs that assess the risk associated with prospective clients. And Applied Expert Systems (Cambridge, Mass.) sells a personal financial planning system aimed at independent planners, consumer finance companies, and companies interested in offering planning services to executives.

At the moment, several factors restrain growth in the applications market. Programs are expensive because of high development costs; Palladian's software, for example, costs around \$100,000, and a company usually finds it has to spend additional money on consultants and in-house programming efforts to install and fine-tune the program. In addition, expert systems typically run on symbolic-processing computers, which generally cost \$40,000–\$100,000 for a system that supports only a few users, and they cannot easily be tied into conventional software and databases. "There is yet no expert system that you can simply buy, plug in, use to

Revenues from expert system applications (\$ millions)



SOURCE: AIM

automatically access the corporate database, and then run," says Neal Goldsmith, a research analyst with The Gartner Group (Stamford, Conn.).

In certain niches, however, companies have been able to justify the expense of purchasing an expert system and adapting it to their particular needs, says AIM president Susan Messenheimer. It's no coincidence, for instance, that most vendors have currently staked out the financial services and insurance industries, where deregulation and bull markets have fueled a boom in business. Expert system vendors hope that the shortage of professionals in such areas,

along with the high payoffs associated with financial problem solving, will allow companies to justify the high purchase prices. Manufacturing applications, in which programs could determine the most efficient way to stock a warehouse or ship an order, are another target, adds Messenheimer. She expects revenues from this sector to catch up to financial applications by 1991, followed by the market for expert systems that can automatically write conventional computer programs.

Two developments should help expand the applications market over the next few years. "We'll get a huge boost when our products can run on desktop computers," says Chayim Herzig-Marx, corporate vice-president at Palladian. That could happen as such machines become more powerful and less expensive, and as expert system vendors learn to efficiently translate their packages into conventional programming languages. In addition, large vendors of conventional application software are closely watching developments in the industry with an eye to embedding expert system technology in their own product lines. Atlanta-based Management Science America, for example, claims that within a year it will bring out an expert system for IBM mainframes to compete in the financial

area, and Cullinet Software (Westwood, Mass.) is said to be acquiring an expert system tool vendor that will bring it into the applications market. Major players like these will offer serious competition to some of the current expert system vendors, but their presence could also stimulate the market. □

—David H. Freedman

"The expert system vendors that will survive and prosper will be those that can develop and deliver a ready-to-run solution well targeted to a specific business problem."

*Sheldon Breiner, President
Syntelligence*

DATABASE SYSTEM UNDERSTANDS ENGLISH

Managers at Home Owners Warranty (Washington, D.C.), like their counterparts in many other companies, had a love-hate relationship with their computer. The company's Honeywell minicomputer held important information, but it took a data processing professional to write programs in order to extract it in usable form; the staff could not easily interact with the machine to make it generate ad hoc reports on demand. Today, under a new computer system, the managers can effectively generate such reports through the use of a familiar language: English.

About two years ago, when the time came to upgrade the minicomputer—to an IBM 4361 mainframe running the VM operating system—the company acquired Intellect, a software package from Artificial Intelligence Corp. (Waltham, Mass.) that accepts typed-in English-language queries, interprets them, and retrieves the desired data. With that system, information center analyst Linda Farrell built a major database query application now used regularly by 28 company managers. In addition, with a smaller version of the system called Intellect SX, other employees in the company have developed their own private application programs—18 in all.

Natural-language processing systems like Intellect are in some ways specialized expert systems; their area of expertise is interpreting the meaning of English-language sentences. Like expert systems built for other applications, most natural-language products contain a mixture of rules (in this case, rules about grammar and sentence parsing) and facts (here, the definitions of words stored in a dictionary, or lexicon). When a user types in an English-language query, the system analyzes the sentence structure and the meanings of the words within it to determine its overall meaning. Most sentences can be interpreted in several ways, and the natural-language system may employ its knowledge of the application to help it home in on the desired meaning. If ambiguities still exist—does “New York” refer to the city or the state?—the system can explain the problem to the user and ask for clarification.

Interpreting the queries is just the first part of the system's job. Next it must translate the sentence into the database query language understood by the computer so that the correct information can be retrieved. In the case of Home Owners Warranty, the database is built and maintained with the IDMS database management product sold by Cullinet Software. Intellect doesn't offer an interface for IDMS's query language, however, so the IDMS files must first be converted with a utility program into DFAM (Disk File Access Method), a standard format that Intellect can access. “Having to create the DFAM files is an inefficient way to do things,” says Farrell, but she notes that Artificial Intelligence is now working to produce a direct interface to IDMS.

Home Owners Warranty provides a warranty program in which home builders around the country enlist. By paying the company a premium, based on the value of the homes they build and other factors such as the length of time the builder has participated in the program, the builders can offer buyers

a 10-year warranty—total coverage for the first two years and coverage for major structural defects for the remainder of the term. To conduct its operations, Home Owners Warranty maintains five major files in its database: listings of the builders, disputes, claims, local councils (the firm's regional offices), and a summary file listing each builder's name, his total number of claims, their dollar amounts, and other relevant information.

To apply the Intellect package to any specific problem domain, the user must construct an additional lexicon containing the words relevant to that application and its database. Thus managers at Home Owners Warranty can type in questions such as “How many builders in New Jersey have open claims?” and the system will quickly supply the answer. “Prior to getting Intellect,” says Farrell, “that kind of information was just not available without having to run a special sorting program.” Not even so-called fourth-generation programming languages that are English-like but still require the user to follow rigid formatting procedures can compare with the natural-language program, she says.



JOHN TROHA/BLACK STAR

Farrell of Home Owners Warranty says the Intellect system lets managers interact with computers in everyday English.

Farrell teaches classes to employees who want to build their own applications using the SX version of Intellect. The two versions operate identically, she says, but differ in the number of database records they can support. The company's main application, for example, contains about 200,000 records; the smaller SX applications tend to have fewer than 1000.

One problem with the initial introduction of Intellect at the company, admits Farrell, was that “I was so enthusiastic that I made the mistake of setting people's expectations too high.” As a result, some users were frustrated when the system was unable to respond to questions outside its domain of expertise. Since then, she has made it clear that the system's range is limited: “It won't give them the odds on the football game next week,” she says. But it does give them what they need from the company's database. □

Dwight B. Davis is a senior editor of HIGH TECHNOLOGY.

For further information see RESOURCES, p. 65.

CHEMICAL MAKERS GET

Beset by stagnating markets, stiff competition from abroad, and topsy-turvy raw material costs, the United States' \$230 billion chemical industry is being forced into what could become the most extensive overhaul in its history. And while each company has charted its own future course, virtually every one of them has hitched its star to new technology.

Seeking to retain a competitive position in world markets for big-volume commodity chemicals such as chlorine and polypropylene, some chemical makers have turned to more efficient or lower-cost production processes. Companies with eroded technical or marketing positions in certain commodities have dropped out of those businesses in favor of such high-value products as specialty polymers, electronics chemicals, and instrumentation. And in a move reminiscent of their Japanese counterparts, practically every chemical producer has linked up with biotechnology companies as an entry into pharmaceuticals, medical diagnostics, and gene-spliced agrichemicals. As if to underscore what amounts to a massive recommitment to the business of chemistry, many of the industry's biggest names have recently shed such unrelated ventures as retailing and financial services.

As a result, producers of the 1990s are likely to be leaner and more competitive than today; they will also be better equipped to avoid going the way of the American steel industry, whose fate seems to haunt many chemical executives. "We're in the same position that steel was in 15 years ago," says Lawrence W. McKenna, director of new business development for Monsanto Chemical (St. Louis). The difference, he says, is that today's chemical makers grasp something that their steelmaking brethren apparently didn't: "Too many of them failed to realize that their real business wasn't steel per se, but materials." In this spirit, he says, chemical producers see their "real business" as "finding new ways to break molecules and put them back together."

BASIC WEAKNESSES. Until the mid-1970s, chemicals were widely regarded as one of the strongest segments of U.S. manufacturing.

As the industry matures, it is forging new strategies and technologies to avoid the fate of American steel

— BY H. GARRETT DEYOUNG —

By the end of the decade, however, three basic weaknesses had been revealed: high raw material costs, growing competition abroad, and maturing markets. Those factors have combined to trim average annual industry growth from its historical rate of 2-3 times the rise in the GNP to about the same as the GNP, according to industry analyst Charles H. Kline, president of Charles H. Kline and Co. in Fairfield, N.J.

The oil price shocks of 1973 and 1979 slapped producers with tenfold increases in the price of energy and petroleum feedstocks—increases that most often were only partially recovered in higher product prices. And although every sector of the economy was touched in one way or another by the hikes, few of them were affected as much as the chemical industry, which depended on OPEC for almost 80% of its raw materials.

The problem was compounded by the emergence of aggressive (and often government-supported) chemical industries in several other countries. Over the past few years, for example, Saudi Arabian planners have begun to implement their long-standing plans to sell not only oil and gas but also such value-added petrochemical products as vinyl chloride monomer (used to produce polyvinyl chloride plastic) and ammonia, a key raw material for fertilizers. "The Saudis know they need to find new outlets for their crude oil," says Nicholas E. Lynam, senior vice-president of Unocal's chemical division in Schaumburg, Ill. Similar programs are under way in gas-rich western Canada, Indonesia, Brazil, and Mexico, where the government is readying a \$400-million-a-year expansion program to help private produc-

ers manufacture and export intermediate and finished products, activities long monopolized by Pemex, the state-owned petroleum company.

Altogether, the new facilities could add about 10% to the world's petrochemical capacity, says A. Nicholas Filippello, chief economist at Monsanto—and at a time when U.S. petrochemical capacity is already underutilized by about 12%.

Yet another blow to the industry is that annual growth rates are flat or dropping for many major products (especially fertilizers, herbicides, and other chemicals pegged to the troubled agricultural sector). And while demand is relatively steady or even rising slightly for many commodity plastics, such as polystyrene and polyvinyl chloride, major new applications are likely to be few and far between. "We'll see some growth in new polymers for autos and construction," says Monsanto's Filippello, "but the strongest growth phase in commodities is past."

BIG TONNAGE. Despite a slowdown, commodities are by no means being ruled out by U.S. producers. While planners concede that the growth rates for these products are probably stuck around 2-3% a year, that's still a lot of tonnage—especially in emerging third-world countries. "The basic-chemicals industry is changing, but it isn't going to disappear," says analyst Jeffrey H. Berg at PA Technology, an international consulting firm based in Hightstown, N.J. "There will always be a steady market for these materials, both here and abroad. After all, developing nations don't need new plastic bags; they need chemicals and fertilizers."

Anxious to fill those needs, several companies have apparently refocused on the commodity business and are attempting to develop efficient, low-cost technology. The problem, says PA Technology researcher G. G. Swasy, is that "in commodities you need a unique technological twist to be profitable. Phillips did it with some of their catalysts, and Union Carbide did it with its Unipol process [a low-pressure method for producing polyethylene and polypropylene, first developed in 1968]. But innovations like these don't come along very often."

IN SHAPE FOR THE '90s



Monsanto's plant in Sauget, Ill., typifies the industry's focus on efficiency. Many processes at the plant (the company's second oldest) are now fully computer-controlled.

In many cases, higher efficiency and lower costs stem from such strategies as shutting down old, energy-hungry plants and consolidating operations in a smaller number of newer units. But several important process improvements have also been announced recently.

New heat-transfer fluids from several specialty companies, for example, promise to improve the energy efficiency of many processes by allowing waste heat to be recovered and used. One such fluid, a silicone-based product called Syltherm 800, has recently been developed by Dow Corning in Corning, N.Y., for use in crude oil refining, plastics production, and other high-temperature processes. At Witco Chemical's Bakersfield, Cal., refinery, the fluid (which can be used at temperatures of up to 750° F) carries heat from the refinery to an adjacent cogeneration unit. There it fires a 33-megawatt gas-turbine generator that was previously run by six gas-fired heaters.

Recently developed catalysts are also helping to lower costs, and in some cases are making it practical to revive aging plants in order to make new products. One example is a new catalytic process called Catofin, from the Houdry Division of Air Products & Chemicals in Allentown, Pa. Company sources won't reveal details of the dehydrogenation process (a process that removes hydrogen atoms and so converts carbon-carbon single bonds to double bonds), noting only that the catalyst itself is a metal oxide on alumina. One Catofin application being promoted by the developers is to convert a chemical called isobutane to isobutylene, which is a key intermediate in the production of the gasoline-octane enhancer known as MTBE. As a result, says Houdry, isobutane plants that were shut down because of low demand can now be easily reconfigured to produce isobutylene, for which demand is much higher.

New membrane technology for economical waste treatment and product separations is yet another area of intense research. One recent example is a so-called bipolar membrane, developed by Allied-Signal Aquatech Systems (Mount Bethel, N.J.), that converts process wastes into recyclable products. The device consists of a thin layer of water between two

membranes, each of which is connected to an electrode. An applied electric current splits the water into hydrogen and hydroxyl ions, which combine with various types of wastes passing over the membrane to form a recoverable acid and base. The process is now being used to treat wastes from metal-plating operations, but could also be extended into a variety of other inorganic-waste processes.

Other changes revolve around new business strategies through which major companies consolidate their marketing positions. For example, Amoco Chemicals in Chicago (a division of Amoco Corp., formerly Standard Oil of Indiana) has taken advantage of its position as a top petroleum company by becoming the world's largest producer of purified terephthalic acid, a feedstock for polyester fibers; it is also among the nation's top three producers of high-density polyethylene (used for milk bottles and other consumer items), and in 1985 it became the nation's top supplier of polypropylene with its acquisition of Gulf Chemicals' capacity.

Obviously, not every company can be the most efficient or run at the lowest costs. Most analysts thus predict a sharp reduction in the number of such producers as the less competitive of them drop out of the picture. As a result, according to analyst Kline, the U.S. will have no more than eight producers of each major commodity chemical by 1995, down from as many as 20 producers of each commodity today.

CARVING NICHES. Many chemical companies are counting on specialty products for higher growth rates. Relative to commodities, specialties are sold in lower volumes ("five-gallon pails instead of tank cars," says one source) but at much higher prices. And while they account for only about 25% of the industry's total sales, says Kline, their annual growth rate averages about 7%—nearly twice that of commodities.

"In commodities there's nothing to distinguish your product from anyone else's," says Swasy at PA Technology. "One tank car of sulfuric acid is the same as any other tank car. But sell very high-purity acid for etching silicon wafers and you've got a product that's bought on performance, not chemical structure."

For example, says Filippello, Monsanto's restructuring during the early 1980s followed from the company's realization that it would probably never become an industry leader in petrochemicals. Thus, while the company remains the world's largest producer of maleic anhydride (used in polyester resins) and has recently joined with Du Pont to develop new manufacturing processes and markets for the

chemical, it has dropped some \$2 billion worth of commodities business since 1981. The operations abandoned include much of its petrochemical-related business (such as styrene and acrylonitrile, used in plastics manufacture) and its crude oil and natural gas ventures. "Six years ago, about 25% of our assets were tied to commodities; today it's only about 3%," says Filippello. "The result is that in

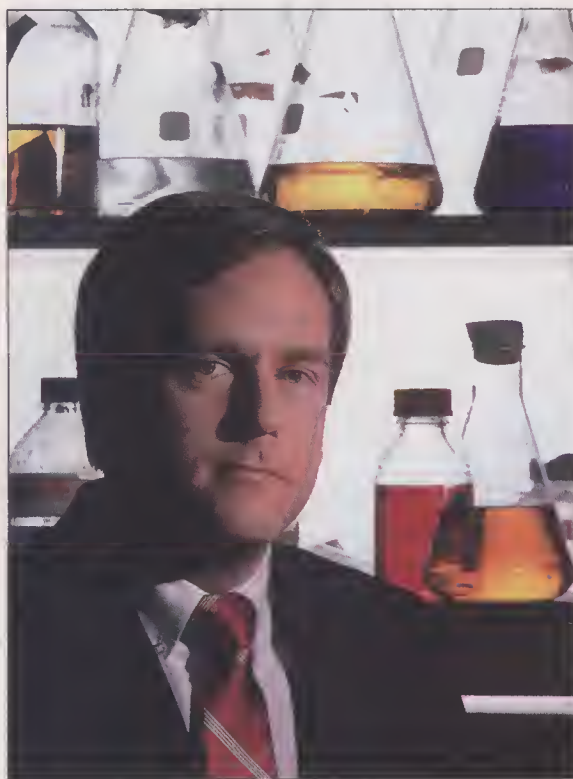
high-impact items as snowblowers, power tools, and sporting goods. Future markets include automotive applications such as wheel covers and mirror housings. The payoff for Monsanto, according to program manager Suren D. Khanna, is a potential growth rate of up to 17% per year, versus only 3–5% for most polymers.

Amoco Chemicals is another company turning to new specialties (although, unlike Monsanto, it is also firming up its commodities position). Convinced that plastics have only begun to replace traditional materials such as metal and wood, Amoco acquired Union Carbide's engineering polymers and advanced composites business in 1986. "Plastics will definitely lead the way in chemical growth for the next decade," says John E. Fligg, group vice-president. As evidence, he notes that U.S. plastics shipments in 1984 were, by volume, twice those of steel; in 1974 the shipments were about equal.

Amoco's new products also include a variety of advanced fibers used as reinforcements in lightweight, high-impact composites for aircraft, automobiles, electrical equipment, and appliances. And last year, Amoco introduced a heat-resistant thermoplastic resin (called Torlon) used to manufacture the world's first, albeit experimental, race-car engine based largely on plastics; the engine is produced by Polymotor Research in Fair Lawn, N.J., and may soon be adapted for use on passenger cars.

Meanwhile, Celanese (New York) is tapping its experience in synthetic fibers to produce cell culture systems for manufacturing monoclonal antibodies—immune-system proteins produced by cells called hybridomas and increasingly used in medical diagnosis and treatment. "Because of the value-added nature of these systems, fibers used in this way are 10 times more valuable than if they're used in textiles or other applications," says group vice-president Richard M. Clarke.

The systems consist of clusters of long, hair-thin hollow fibers enclosed in plastic or glass cylinders. The hybridomas are placed into the cylinders and fasten onto the fibers, where they are fed by a constant flow of nutrients. Because of the high surface area provided by the fibers, the hybridomas grow to very high densi-



VP Patrick Connoy of Integrated Genetics; which has teamed up with Amoco to develop new medical diagnostics.

every one of our businesses we're either number one or a strong number two."

One result of the shake-up is a new family of engineering thermoplastic polymers (called Triax) with much higher resistance to heat and physical impact than conventional thermoplastics. The materials are based on a proprietary technology in which dissimilar polymers are permanently combined in much the same way that oil and water are combined with an emulsifier; in theory, the process allows formulators to create new alloys from virtually any combination of polymers. First a "compatibilizer" is reacted with one of the polymers, then this two-part solution is reacted with the second polymer; custom-tailored chemical groups in the compatibilizer form strong "bridges" from one polymer to another.

The first such product—called Triax 1000, an alloy of nylon and a polymer called ABS—is now being sold for such

ties and produce correspondingly large volumes of antibodies.

A DIFFERENT CHEMISTRY. The Celanese cell culture system is just one example of chemical companies' growing interest in the new molecules of biotechnology and healthcare. There are at least two reasons for that interest. One is that biotechnology is

Do U.S. companies have the patience to back products that may not pay off for years?



PETER VIDOR

perceived as the leading edge of new technology. Says Monsanto corporate vice-president S. Allen Heininger, "This is where most of the breakthroughs will happen during the '90s. And biotechnology is chemistry—a different kind of chemistry, to be sure, but chemistry nonetheless."

The second reason is pure profits. "Pharmaceuticals are very lucrative," says Jeffrey L. Sturchio, associate director of the Center for History of Chemistry (Philadelphia), "and every chemical company wants to stay very close to them. The way you do that is through biotechnology."

One way of "staying close" to the technology is through acquisition. When Monsanto bought pharmaceutical maker G. D. Searle (Skokie, Ill.) in 1985, for example, it not only gained the commercial rights to Searle's aspartame (the synthetic sweetener marketed as NutraSweet) but also stepped up its potential to become a formidable force in healthcare. Filippello notes that while Searle was ranked as the nation's 35th-largest pharmaceutical company in 1985, "we plan to put it into the top 20 by 1990." Current Searle research programs are targeted at

In its quest for "value-added" technology, says Richard M. Clarke, Celanese is pegging its synthetic fibers to new cell-culture systems for biotech firms.

neurological and psychiatric disorders, coronary disease, and hypertension.

Monsanto is also developing new crop-genetics technology, which could be commercialized as early as 1991. To that end, corporate genetic engineers are now working on crop seeds that will be resistant to Roundup, a Monsanto herbicide based on a chemical called glyphosate. Once it is taken up by plant cells, glyphosate destroys the plant by interrupting the formation of a critical plant enzyme. In theory, crops grown exclusively from the glyphosate-resistant seeds—which will probably be sold through major seed companies—can be weeded with just one or two treatments of Roundup, rather than with multiple treatments with several different herbicides as is done now.

Other companies have ventured into the life sciences by teaming up with small R&D firms that have strong proprietary positions in one or more biotechnology areas. Last summer, for example, the chemical division of Eastman Kodak (Roches-

ter, N.Y.) announced a joint program with Engenics in Menlo Park, Cal., to develop high-protein food additives for animals and humans. The program calls for Engenics—a two-year-old private company specializing in bioprocess techniques—to develop new genetically engineered microbial strains and design a pilot plant; Kodak's Bio-Products division will scale up the design and oversee regulatory and marketing activities. The first products from the \$2 million venture are expected by early 1988 (see "Expanding the bioprocessing market," p. 12.).

Meanwhile, Celanese has formed two new companies with outside groups—Celgene (based in Summit, N.J., and created in partnership with a small group of private investors) and Novacel, a joint venture with Nova Pharmaceutical in Gaithersburg, Md. Clarke explains that while Celgene is still in a start-up phase, research will probably focus on new pharmaceutical processes; for example, the company has recently developed a novel, low-cost process for manufacturing the aspirin substitute acetaminophen.

Novacel is now developing drug delivery systems in which drugs are incorporated into implantable polymers. One such system, containing an antitumor drug and designed in cooperation with MIT researchers, is now being tested in brain cancer patients. The polymer is implanted near the tumor and slowly releases the drug to the cancerous cells, then breaks down into harmless starchlike molecules. "Like most of our joint ventures," says Clarke, "this was a logical extension of our experience in fibers and polymers."

Similar projects are under way at Pittsburgh's PPG Industries. Acknowledging the maturity and slow growth rates of its traditional product lineup—including chemicals, glass, and coatings—PPG is now in the second year of a 15-year, \$120 million joint research program in plant biology with the Research Institute of Scripps Clinic (La Jolla, Cal.). Under the program, PPG hopes to translate Scripps's basic plant research into safe and more effective new herbicides and plant growth regulators.

Researchers at PPG and Scripps are now trying to develop a class of herbicides that are harmless to all forms of life except target weeds. To do that, says PPG president Edward J. Slack, it is necessary to identify and isolate proteins unique to

the target plant, then develop a herbicide that inhibits only those proteins. Development is expected to continue throughout the decade, with commercialization expected in 1990-92.

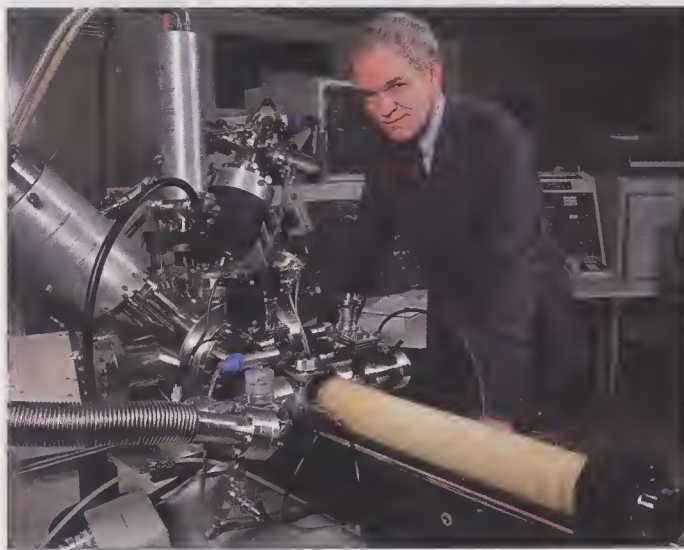
And Amoco Corp. has entered a \$20 million joint venture with Integrated Genetics in Framingham, Mass., to develop DNA probes for medical diagnosis. In this technology (to be funded by Amoco), researchers create segments of DNA that bind to complementary segments from a bacterium or other organism. When the probe is added to a patient fluid sample that contains the target DNA, the probe unites with it, creating a visible or measurable change. About half a dozen probe-based diagnostics are now on the market, and analysts predict annual sales of more than \$1 billion by the early 1990s.

Biotechnology might also one day play a role in the production of commodity chemicals. Most of the experimental routes are based on biomass conversion, as when microorganisms convert the sugars in agricultural wastes to ethyl alcohol, which may in turn be converted to such chemical intermediates as olefins, aldehydes, and ketones. Another example is an enzymatic process that could, in theory, be used for converting the common intermediate phenol to catechol, which is used as an antioxidant in rubbers and plastics. In this procedure, the gene for an enzyme called phenol hydroxylase would be inserted into bacteria; when added to the reaction, the enzyme secreted by the bacteria would precisely add a single -OH group to the phenol. The process is potentially much less expensive than conventional chemical methods, and could also run at much lower temperatures and thus require less energy.

Such techniques have garnered much more interest in Japan than in the U.S., however, largely because of that country's paucity of natural resources; most observers doubt that large-scale biological processes will soon be employed in the U.S.—partly because of better raw material supply and partly because of the cost of replacing plant equipment based on oil and gas processes. "It might make sense if oil reaches \$50 or \$60 a barrel," says Monsanto's Heininger. "But we doubt that prices will rise much over \$18 a barrel between now and the end of the decade." Another problem with biomass conversion, he says, is that alcohols—the invariable starting point—are rich in oxy-

gen: "If you want to convert the alcohol to ethylene or propylene, you have to first go through several steps to get rid of the oxygen, and that will be costly."

KNOTTY ISSUES. Extensive though the restructuring is, the chemical industry clearly has plenty of problems left to solve. One of the most pressing, according to Heininger, is to demonstrate to the American public that the industry is addressing the knotty issue of chemical waste treatment and



Monsanto's Lawrence W. McKenna (top) and A. Nicholas Filippello: By finding "new ways of making molecules," the company has slashed its reliance on low-growth commodity chemicals.

disposal. Several promising technological solutions have been developed—recycling of some types of wastes, for example, and incineration of others—both by chemical producers and by the growing number of companies specializing in waste treatment. However, says Heininger, the issue is complicated by such factors as community resistance to new treatment facilities (the "not in my backyard" syndrome) and still-evolving federal regulations.

Just as uncertain is the commercial out-

look for the industry's upcoming biotechnology-related products and processes, especially in view of competition from abroad—most notably Japan, where such chemical and food-processing giants as Mitsubishi, Asahi, and Kirin Breweries have well-funded programs in pharmaceuticals, diagnostics, and crop genetics. Industry sources are reluctant to paint marketplace scenarios. "This is such a young field, with so many different applications, that I don't think anyone knows at this point how it's all going to end up,"

says Kline and Co. project manager Steve Daigle. Nevertheless, he says, international competition during the 1990s is likely to be at least as intense as the rivalries typical of the commodity chemicals market. And although American biotechnology is widely perceived as being slightly ahead of Japan's, Daigle and others worry whether U.S. companies, with their insistence on quick returns, will have the patience to stick with products that may not pay off for several years.

Nor is the trend toward product specialization a sure cure, says Amoco's Fligg:

"There are bad specialty areas, just as there are weak commodity areas." Moreover, many large chemical companies have found that diversifying into a new line of specialties is more difficult—and often much more costly—than they realized, especially if the diversification is via the usual route of acquiring a small company. "For many of these smaller companies, annual sales of \$25 million is a big deal," says Kline's Daigle. Yet such numbers become almost insignificant inside a \$5 billion company, and too often fail to justify the problems—such as personnel conflicts and a breakdown of rapport with key customers—that frequently follow acquisition.

Still, chemical makers speak today with a decidedly optimistic tone—a sense that they've stripped down for action and set themselves logical, realistic goals for the 1990s. "This is one of the few technical businesses in this country with a positive balance of trade," says Sturchio at the Center for History of Chemistry, "and it has more than a hundred years' experience in solving its problems. There's no reason to think it's about to stop now."

H. Garrett DeYoung is a senior editor of HIGH TECHNOLOGY.

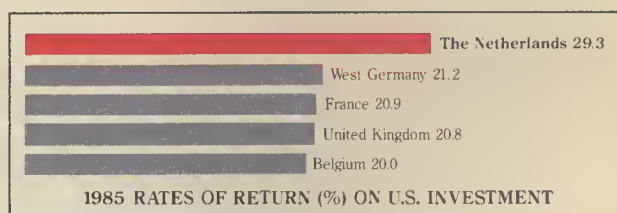
For further information see RESOURCES, p. 65.



BUT ALSO CHEMICALS, PLASTICS...

THIS IS THE NETHERLANDS: Not only the second largest exporter of agricultural products in the world, but also a major manufacturer and exporter of industrial and consumer items. Many U.S. corporations manufacture in the Netherlands for their international markets, including:

- INTERNATIONAL FLAVORS AND FRAGRANCES—exports flavors, fragrances and aroma chemicals worldwide from its three Dutch plants, representing its *largest overseas investment*.
- WITCO—manufactures white oils and other specialty chemicals for Europe, Africa and Asia in Koog a/d Zaan, its *largest overseas investment*.
- GENERAL ELECTRIC'S PLASTICS GROUP—supplies Europe, Asia and Africa with engineering thermoplastics from Bergen op Zoom, GE's *largest overseas investment*.



The average rate of return on U.S. direct investment in the Netherlands has been much higher than the European norm throughout the 1980s.

ARE YOU IN THE NETHERLANDS YET?

If not, please contact:
 Mr. Pierre Dobbeltmann
 Executive Director
 United States & Canada
 Netherlands Foreign Investment Agency
 One Rockefeller Plaza
 New York, NY 10020
 (212) 246-1434

The Netherlands
 Right
 in the
 Center
 For Investment

This announcement is published by Gavin Anderson & Company, which is registered as an agent of the Government of the Netherlands. This material is filed with the Department of Justice, where the required registration statement is available for public inspection. Registration does not indicate approval of the contents by the United States Government.

Circle No. 29 on Reader Service Card.

"It took the company that invented the copier..."



Xerox 914—1959.

Xerox introduces the 1065 Marathon copier.

Since Xerox invented the original copier nearly 30 years ago, everyone's been trying to copy us. But now, we've literally redesigned the copier from the inside out, for the most spectacular copies you've ever seen.

Each copy a masterpiece.

Everyone tries to make copies that look as good as the original. But how

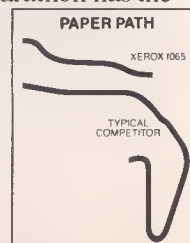
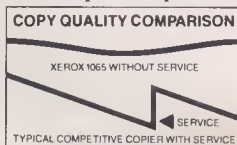
about copies that look *better* than your originals? The 1065 Marathon produces the cleanest, sharpest copies

ever. And our breakthrough microprocessor technology keeps them looking that way, month after month, with little or no professional adjustment.

Genius doesn't have to be temperamental. Now, frequent

paper jams are but a distant memory. Because the 1065 Marathon has the shortest, straightest paper path in its class. That means instead of wasting your genius clearing paper jams, you can use ours to make copies.

A revolution in productivity. Most competitive copiers lose



XEROX

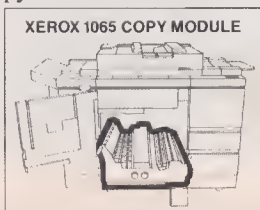
to reinvent the copier.” Leonardo da Vinci



Xerox 1065 Marathon—1987.

Circle No. 45 on Reader Service Card.

up to 85% of their speed when they copy two-sided originals. But the 1065 maintains its speed no matter what kind of job you're performing. And our unique copy module cuts down servicing time by up to 50%. So you can be as prolific as your genius allows.



A new age in copying. The 1065 Marathon is the most intelligent copier in its class. That makes it as simple to use as pushing a button. But, if you do have any questions, you can count on the expertise and support of Team Xerox.



To find out more about the newest generation in copying, call the only company that could have created it. 1-800-TEAM-XRX, ext. 168B.

Xerox brings out the genius in you.

I'd like to learn more about the new Xerox 1065 Marathon copier.
☐ Please send me more information.
☐ Please have a sales representative contact me.
 Send this coupon to:
 Xerox Corporation, P.O. Box 24, Rochester, NY 14692.

Name _____ Title _____
 Company _____
 Address _____
 City _____ State _____ Zip _____
 If you can't wait, call
1-800-TEAM-XRX, EXT. 168B
 168B (1-800-832-6979, ext. 168B). 184-4-87

XEROX®, 1065 and 914 are trademarks of XEROX CORPORATION.

GETTING A HANDLE ON PORTABLE COMPUTERS

***Laptop machines are catching up with desktop models,
but trade-offs persist between size, performance, and battery life***

BY CARY LU

The first truly portable computers began appearing in 1982. With their modest features, these early models were more tantalizing than convincing, yet the goal was obvious: a small, battery-operated unit that could match the features of a standard desktop microcomputer. Now that goal has been achieved—sort of. You can buy a portable in 1987 with most of the amenities a desktop computer had in 1982.

The market has broken into several segments:

- *Lightweight portables (under five pounds).* In this category the Tandy Models 102 and 200 (and earlier Model 100) are the best known. These portables require special software, for they lack the computing power to run standard desktop software. But they feature long battery life—well over 10 hours on ordinary AA cells.

- *Medium-weight portables (five to 10 pounds).* Running modified versions of MS-DOS programs, these include the Tandy Model 600 (with a set of Microsoft applications in ROM) and the Hewlett-Packard Portable Plus (with a custom version of Lotus 1-2-3). As newer portables

appear that can run unmodified IBM PC software, these machines are falling out of favor.

- *Heavyweight IBM-PC compatible portables (10 pounds and over).* These machines now make up the fastest-growing sector of the market. Built by IBM, Toshiba, NEC, Zenith, Datavue, and many others, they can run any standard software for the IBM PC. Because of size limitations, none can accept internal expansion boards designed for the IBM PC, but many come with 640 kilobytes of random-access memory (RAM) and allow space for an internal modem.

Beyond these highly visible models, a surprisingly varied array of other truly portable designs are sold, mostly through value-added resellers who bundle specialized software. A dozen companies make portables designed for collecting data in harsh environments; these models typically have membrane keyboards and are sealed against dust and moisture. A few portables are still sold that work on the old eight-bit CP/M-80 operating system standard that preceded the IBM PC.

To be a true portable, a computer

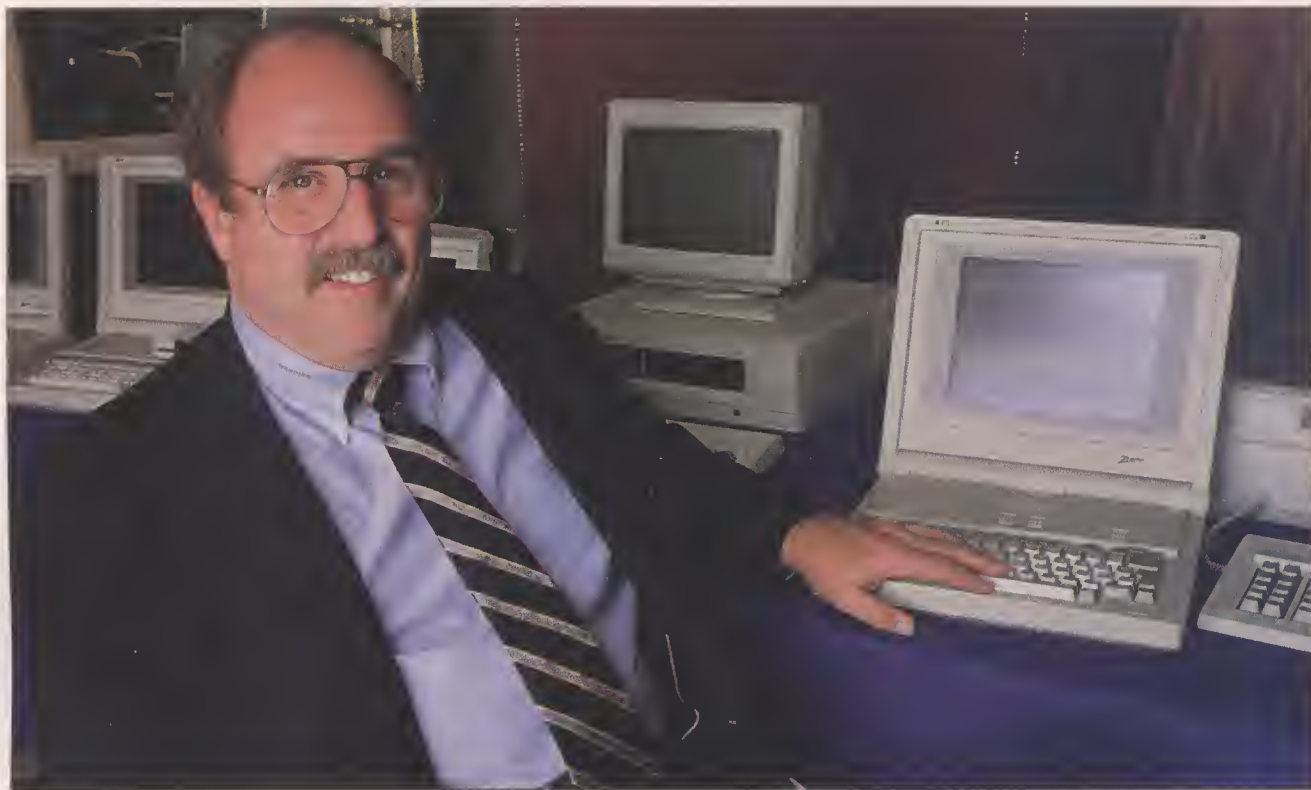
should be able to run on internal batteries for hours—at least as long as a transcontinental flight (say, six hours). But many models fall short.

There is also a fragmented quasi-portable market, consisting mostly of machines such as IBM PC compatibles and modified Macintosh computers that require ac power for their displays and hard disk drives. And a few over-20-pound ac-powered transportables, first popularized by Osborne and Compaq, are still being lugged around, but these are now fading from the scene as more users acquire two computers—one desktop and one true portable.

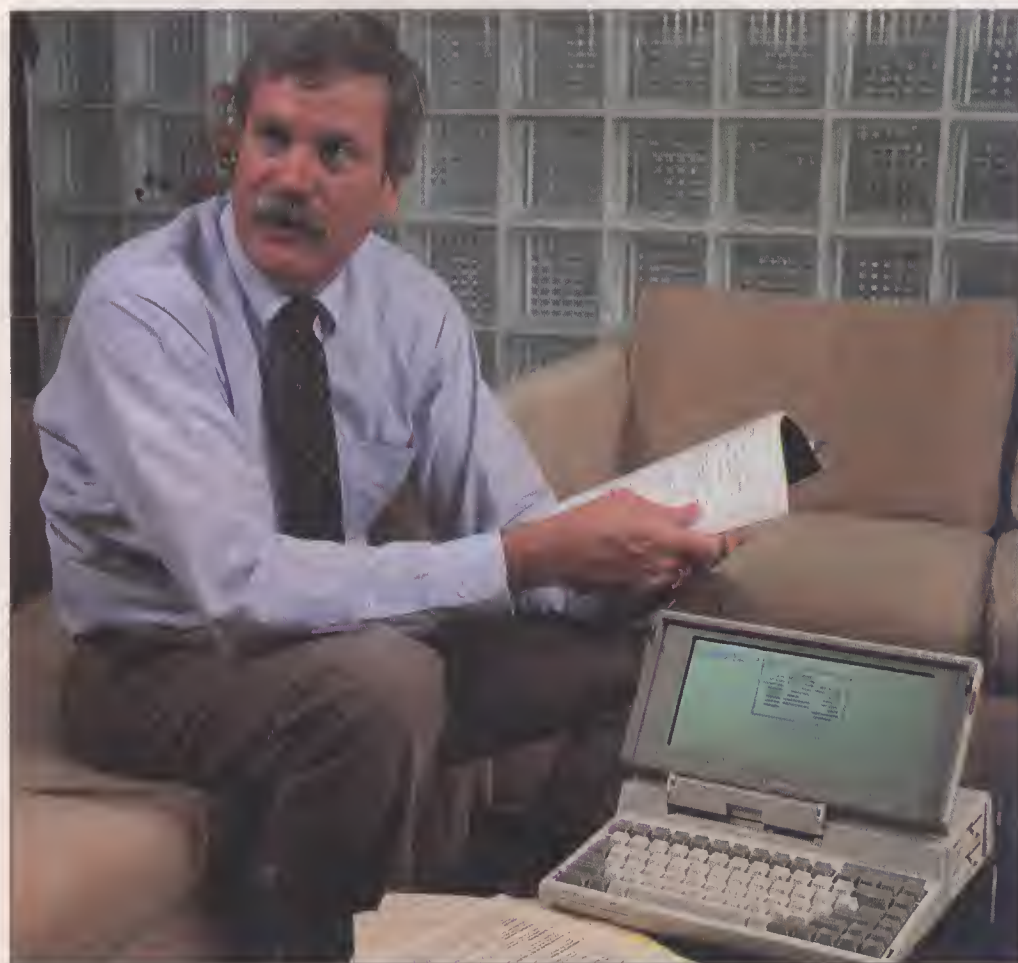
Because no component is yet perfect for portables, designers have had to make trade-offs in weight, size, power requirements, and cost. This has yielded a portable computer crop far more diverse than its desktop counterpart.

Here are the design issues for the major components today:

DISPLAY. Over the past five years, displays have improved considerably, but they are still the single biggest challenge in



Above: Zenith president Bob Dilworth shows off the Z-181, which features a backlit LCD. The back-light limits battery life but produces a bright, legible display.



Left: Dan Crone of Toshiba with the 1100 Plus, the first successful IBM PC compatible that's also a true portable, now updated with a supertwist display.

portables. Of the technologies available today, only liquid crystal displays (LCDs) require little enough power—as low as 80 milliwatts—to be suitable for portables.

The many LCDs on the market vary in several important ways. One is the number of text columns. Since a reflected-light LCD is difficult to read, a 40-column display has an important advantage over the 80-column variety simply because the characters are larger. While MS-DOS/PC-DOS does have a 40-column display mode, virtually all microcomputer software assumes an 80-column display.

Another consideration is pixel count. All full-size LCDs (80 columns by 25 text lines) currently have 640 by 200 pixels, the same as the IBM Color Graphics Adapter (CGA). This is not enough to produce a quality image, but it is all you can get in today's portables. New LCDs that should appear within a year will have 640 by 400 pixels, enough to handle IBM Enhanced Graphics Adapter (EGA) images, offering a big improvement over present displays. The EGA image is actually 640 by 350 pixels, but the controlling software will turn off the last 50 lines or provide a way for specific software packages to use all the pixels. Although some ac-powered quasi-portables already have 640- by 400-pixel screens, they so far lack either EGA operation or drivers to take advantage of their nonstandard display format.

Manufacturers have developed LCDs with pixels in two aspect ratios (height: width). A 1.6:1 aspect ratio (as on NEC's MultiSpeed and Zenith's Z-181) yields rectangular pixels that have the same proportions as an IBM CGA image on a typical CRT; a circle generated by a graphics program for a CGA display on a CRT will therefore look like a circle on the LCD. But with this aspect ratio, the screen must be tall, making the entire computer bulky. Meanwhile a 1:1 aspect ratio (as on the Toshiba 1100 Plus) yields square pixels that allow a shorter screen, but a circle created for CGA's rectangular pixels is flattened into an ellipse and character height is reduced.

The big news in LCDs recently has been the introduction of "supertwist" displays. When active, a liquid crystal changes the polarization of light; a supertwist crystal changes the polarization by 270° instead of the 90° in the earlier twisted nematic LCDs, resulting in higher contrast and a wider viewing angle. Supertwist screens are enough of an improvement that most portable computers will switch over to them by this summer. They show adequate contrast for a limited gray scale, so colors generated by software can be displayed as shades of gray. Although a supertwist display can be improved by backlighting, such illumination burns about 5 watts, seriously shortening the life of the

batteries (in the Zenith Z-181 they last about four hours). You can turn off the backlight for a few extra hours of operation, but because these screens are designed for transmitted light, the result is poorer contrast than on a screen designed only for reflected light.

Supertwist LCDs are hardly the ultimate in screens; many other LCD variations are under development. Smectic-C LCDs, based on materials whose molecules tilt in either of two directions in response to a voltage, have similar image qualities but much faster response time than supertwisted screens. Color LCDs with enough pixels for computer displays should be available within two years, aided by advances in thin-film technology, which will allow a transistor switch for each row of pixels to be built right on the LCD substrate. The switch will keep a pixel turned on or off as needed—unlike present LCDs, where a controlling voltage scans each row of pixels sequentially and turns a specific pixel on only briefly during each scan. Pixels with a continuous on or off state will produce higher contrast.

Two high-power flat-screen display technologies have made it into production. Plasma displays essentially work as

inch spacing between keys (measured from center to center) that has long been established in typewriters; narrower spacing—as on Data General's models—makes a computer harder to use.

Portables do not have enough keyboard space for a standard IBM PC layout, so all function keys, cursor keys, and so on must be shoehorned around the typewriter keys. Since no portable computer keyboard is laid out exactly like a desktop model, reflexes developed on one cannot be transferred to another. NEC's MultiSpeed comes closest to the IBM layout, with its numeric keypad and cursor keys above the right side of the keyboard and function keys in two vertical rows on the left, but this layout is nearly two inches wider and three inches deeper than the most compact designs.

One area where nearly all portables fail is keyboard feel. Most portable keyboards are now made in Asia, where few people—certainly not the keyboard designers—know how to type; no Asian manufacturer seems able to produce a keyboard with an acceptable feel. This is the only area where the IBM Convertible has a clear advantage over its competition.

***You can buy a portable
in 1987 with most
of the amenities
a desktop computer
had in 1982.***

an array of tiny neon lights and offer higher contrast than any LCD, but their power requirements—15 to 20 watts, 200 times that of an efficient LCD—are too high for portables. Plasma panels cost about three times as much as a supertwisted LCD, but 640- by 400-pixel panels are readily available. Electroluminescent (EL) screens boast images better than plasma screens or even CRTs. Unfortunately, EL consumes as much power as plasma and costs about 20% more. It's unlikely that either plasma's or EL's power requirements will drop far enough to be suitable for battery operation.

Because display technology is changing rapidly, portables that feature user-replaceable screens have a significant advantage, provided the manufacturers actually deliver alternative screens.

KEYBOARDS. After screens, keyboards have proved to be the most difficult component to design into portable computers. Keyboards must have the standard ¼-

PROCESSOR AND MEMORY. To conserve power, a processor for portables must be made in CMOS (complementary metal-oxide semiconductor) instead of the cheaper and more common NMOS (n-channel MOS). An NMOS 8088 microprocessor chip, as used in a desktop IBM PC, consumes about a watt; a CMOS 80C88 consumes only about 150 milliwatts. For more complex processors, lower power consumption reduces heat dissipation problems, so some designs such as the 80386 are available only in CMOS. (The 80386, however, takes 2 watts to run; for use on a portable it would probably have to be revised for lower power consumption.)

The Motorola 68000 processor, used in the Macintosh, Amiga, Atari ST, and other micros, is out in CMOS form from Hitachi, but a complete set of necessary supporting chips is not yet available in CMOS, and no true portable based on the 68000 has appeared.

Everyone wants computers, including portables, to operate faster. Several companies point with pride to their processor speed of 7.16 or 9.54 MHz, versus the standard 4.77 MHz of the original IBM PC. A faster processor is always handy, although this is only one of several factors that affect overall computing speed. But speed imposes a serious penalty on portables: the faster a CMOS processor runs, the more power it consumes. Twice the speed means about twice the power. NEC's MultiSpeed, for example, can oper-

ate only for about four hours at 9.54 MHz, but runs for more than six hours at 4.77 MHz (battery life does not double, since the display and disk drives consume the same power regardless of processor speed). The trade-off between speed and power consumption could conceivably lead some manufacturers to consider slowing their processors to below 4.77 MHz. Users will be able to select processor speed for their specific requirements: for functions such as note taking, slowness should not matter much, but some software will not work well if run on a slower processor.

Like processors, memory also comes in two common forms, dynamic NMOS and static CMOS. Power consumption comparisons are hard to make because of variations in circuit design and usage, but NMOS memory takes about 10 times the power of CMOS. When not actively used for computing, CMOS memory can be preserved in a standby mode that needs so little power—a few microwatts for some chips—that it can store data for days or weeks with just a small battery. Some portables with CMOS RAM as the main memory can be switched to standby operation and the memory contents preserved for re-starting at the same point later—a feature not available on most desktop computers. The small laptops such as the Tandy Models 102 and 200 have so little memory—32 to 104 kB—that all of it can be CMOS for a reasonable price. The 640 kB of memory now standard on IBM PC-compatible portables costs a lot more if it is all CMOS. As a result, many of these machines use standard NMOS memory and do not attempt to preserve any memory with battery backup. NEC splits the 640-kB memory of its Mul-



MIKE ABRAMSON

Left: Keith Schaffer of NEC with the MultiSpeed, a portable with a relatively spacious keyboard layout.



CHUCK ROGERS

Below: Datavue has been an aggressive U.S. designer of portable computers; Leland Strange shows off current models, including the modular Snap.

tiSpeed into 128-kB static CMOS RAM with battery backup and 512-kB without. Thus, in standby mode, the MultiSpeed can save only files that fit into the 128-kB RAM "disk" and that don't need to be preserved for more than a week; everything else must be saved on a real disk.

Read-only memory (ROM), on the other hand, requires no power at all to hold its contents, and can store programs without the bulk, weight, and power requirements of floppy disk drives. The Tandy Models 102, 200, and 600, as well as other computers with special software, use ROM for program storage; the NEC MultiSpeed also has several simple ROM application programs, although you must boot the computer from a disk before they will run. Conventional MS-DOS software cannot always be put in ROM; the code of many programs, for example, is actually modified during operation.

DISK DRIVES. Lightweight portables cannot incorporate a floppy disk drive, although machines such as the Tandy 102 and 200 can connect to an external drive. All the new PC-compatible

LAPTOP COMPUTERS VIE WITH "LUGGABLES"

Although the market for portable computers never took off as explosively as once seemed possible, revenues have been respectable enough to attract many suppliers to the field. Leading vendors include Data General (Westborough, Mass.), Grid Systems (Mountain View, Cal.), Hewlett-Packard (Palo Alto, Cal.), IBM (Armonk, N.Y.), Tandy (Fort Worth, Tex.), Toshiba (Santa Clara, Cal.), Zenith (Glenview, Ill.), and Compaq (Houston).

These companies currently share a market worth about \$950 million, according to International Data Corp. (IDC) of Framingham, Mass. Approximately 250,000 of the 400,000 units shipped last year—accounting for \$510 million in revenues—were laptop machines, small enough to fit easily into a briefcase. The other 150,000 units, representing \$440 million in sales, were "luggables," much larger and heavier (10–15 pounds) than laptops but typically offering more of the features of desktop computers. By 1990, the total market should grow slightly to \$1.1 billion; laptops will account for 76% of the revenues and for 83% of the 590,000 units shipped in that year.

"A major issue facing portables companies," says IDC analyst Stephen Bosley, "is how to secure or improve market share in a field characterized by many strong competitors." One approach vendors have taken has been to market portables to their own installed base of desktop buyers, on the assumption that familiarity with an office machine predisposes a customer to use a portable from the same firm. Another approach is to differentiate their products from one another, says Bosley, by varying the mix of features that might be built into a portable, choosing from among modems, floppy disks, hard disks, different types of screens, and chip-based software. In effect, users can then purchase machines tailored to match their needs for computing power and portability.

The basic laptop portables dominate the market because "most users don't want to run intensive programs like spreadsheets," says Ed Juge, director of market planning for Tandy, "and casual use isn't going to justify carrying around a 12-pound computer that fills an entire briefcase." Instead, laptop



"Today's high-quality portable computer screens use a lot of power. Whoever develops a very long-lasting battery or a more energy-efficient screen will give a strong push to the portable market."

*Jeffrey L. Swartz
Communications Publishing Group*

machines are being used primarily for taking notes and sending and receiving electronic mail.

However, the market for portables with more features than laptops cannot be counted out. "Including a disk drive or two and a full-sized screen will make a portable bigger and heavier, and adds significantly to a machine's power requirements," says Jeffrey L. Swartz, president of the technology tracking firm Communications Publishing Group (Natick, Mass.), "but it may also let you do more." Users such as writers, programmers, and field service personnel, he points out, may be willing to put up with bulkier machines that better accommodate their needs, as indicated by sales of such computers from Compaq and Toshiba.

Recent advances may make the choice between size and capability less painful. For instance, new electroluminescent and gas-plasma displays are finally giving users lightweight, high-quality screens. At the same time, an increasing variety of portables are using plastic-encased 3½-inch floppy disks, which can hold twice as

much information as today's 5¼-inch disks and are less likely to be damaged. As such, "they are much better suited to the rugged environment in which portables are typically used," says G. Berton Latamore, editor of *VideoPrint*, a newsletter published by International Resource Development (Norwalk, Conn.). These developments, however, carry certain trade-offs. The electricity requirements of the new screens tie a user to the nearest wall outlet, thus limiting the machine's portability. And information on 3½-inch disks cannot yet be widely shared with desktop computers using larger floppies.

Ironically, if such problems can be overcome and if portables continue to incorporate desktop-like features, customers could eventually adopt the smaller machines for office use. Swartz of Communications Publishing Group, in fact, believes that within 10 years portables could be both powerful and convenient enough to use in the office, yet small and light enough to take on the road. "At that point," he says, "it may make more sense to have just one computer to do both jobs."

—Steven Weissman

portables use 3½-inch microfloppy disk drives in a standard MS-DOS format with 720 kilobytes on a disk. A new microfloppy format storing 1.4 megabytes on a disk will be introduced by this summer; these new disk drives will still be able to read and write the 720-kB format. A microfloppy disk drive consumes about 5 watts in operation but needs to be turned on only during actual disk access. You can thus save power by using the disk drives less often, but you risk losing data if you forget to save regularly.

Floppy drives are the one area where portables are more

advanced than desktop computers. Nearly all desktop models still use the older 5¼-inch disk drives, but all new computers, whether desktop or portable, will emphasize the technically superior 3½-inch microflopies; the older format will slowly die away, just as the earlier 8-inch floppies have disappeared.

Hard disk drives have become standard equipment on desktop computers, but they pose nearly insurmountable obstacles in a portable. A microwinchester hard disk drive consumes 3–10 watts and normally runs continuously. Although a hard disk drive in a portable could be turned on and off as necessary—like a floppy disk—the time required to spin up the disk makes overall access time very long—five seconds. And hard disks are relatively fragile, requiring careful handling.

Wang's LapTop computer is unusual in that it has only a hard disk drive (which can be run either continuously or intermittently); floppy drives are connected externally. But there are inevitable drawbacks. It runs for just two to four hours on internal batteries. And Wang, like Toshiba in its ac-powered 3100, uses a JVC hard disk drive designed for low power consumption and shock resistance but providing much slower access time than ordinary hard drives; faster access requires larger head-positioning motors, which burn too much power.

Because hard disk drives are such a



The Wang LapTop contains a built-in hard disk drive and printer but no floppy disk drive.

A portable should be so small and light that you will take it with you even if you might not use it.

problem for portables, future development seems likely to concentrate on higher-capacity floppy disk drives. Prototype 4- and 8-megabyte 3½-inch microfloppy drives and a new 2½-inch 360-kB floppy format are being tested now and may appear in production portables within the next three years. The 3½-inch drives will be able to read the 720-kB and 1.4-MB formats but will not be able to write them; in many ways they will substitute for hard disk drives in portables.

PPOINTING DEVICES. All IBM PC-compatible portables provide cursor keys as the main way of pointing to objects on the screen. But mice will become increasingly common; although most MS-DOS programs do not use them, modern software requires a mouse or something similar. A mouse is a minor nuisance with portables because it dangles from the end of a wire, and it becomes a major nuisance when you operate a portable on your lap without any hori-

zontal surface for moving a mouse. Designers are trying to develop mouse substitutes for portables (mostly variations on touchpads or small trackballs), but no clear alternative has yet emerged.

CASE DESIGN. Nearly all portables have a hinged lid containing the screen, which folds down over the keyboard. The hinge can be at the rear of the computer or in the middle. A rear hinge (NEC MultiSpeed, Zenith Z-181) allows for a tall screen, where pixels have a 1.6:1 aspect ratio, and an expansive keyboard. But the computer is so

bulky when open that running it in an airline seat is difficult or impossible, particularly if the person in front of you leans back. A middle hinge (Toshiba 1100 Plus) works with lower-profile screens (with 1:1 pixels), which are much more convenient on planes.

WEIGHT AND SIZE. The ultimate requirement for any portable computer is that it be small and light, preferably small and light enough that you will take it with you whether or not you know you will use it. By this measure, most portables fall short of the mark. The weight limit for a portable that you might carry around every day seems to be about five pounds; anything heavier quickly becomes a burden. As for size, a portable computer should not take up more than half a briefcase, so you can carry other items as well. The IBM PC compatibles with disk drives do not come close to meeting these criteria.

The Tandy 102 and 200 do fit the bill, however, and at a mere three pounds and 150 cubic inches, the Model 102 is far and away the most portable useful computer—if its limited software, small memory (up to 32 kB), and diminutive screen (40 columns by 8 rows) meet your needs. The Model 200 is similar to the 102, except for a bigger screen (40 by 16), a built-in spreadsheet, and larger size (4.5 pounds, 220 cubic inches). Traveling Software's

Ultimate ROM adds valuable software functions, including a database and the ability to display 60 columns on the Models 100 and 102.

Datavue has announced Snap, an interesting IBM PC compatible that comes in two parts. The five-pound laptop module is a self-contained computer with 512 kB of CMOS memory but no disk drive. The rear expansion module contains disk drives, 640 kB of NMOS dynamic RAM, and an optional hard disk. You can load programs and data from disks into the lap module and then disconnect the drives and leave them behind, provided that 512 kB is sufficient for your programs and data. Although the prototype Snap has a particularly awkward keyboard layout, and the lap module is rated to run for only four hours on internal batteries, the concept is promising.

The full-featured IBM PC-compatible portables with two internal microfloppy disk drives are much heavier and larger. The Toshiba 1100 Plus weighs in at 10 pounds and takes up 380 cubic inches. Other models fall into the heavyweight class. The Zenith Z-181 tips the scales at 11.8 pounds and 480 cubic inches. The NEC MultiSpeed weighs about 12 pounds and displaces 490 cubic inches. Wang's LapTop with a hard disk and built-in printer weighs 14¼ pounds and takes up 660 cubic inches.

A computer weighing 10 pounds or more is too heavy to take with you unless you are sure you are going to use it. But IBM PC compatibility, complete with disk drives, is not possible in a lightweight package today or in the near future, except in a modular design.

Since most portables are used in conjunction with a desktop microcomputer, many users will have to move information regularly between the two. A few older portables have built-in 5¼-inch disk drives, particularly the "lunch box" designs such as the Morrow Pivot/Zenith Z-171 and Datavue 25. These let you simply exchange disks with a desktop computer. For microfloppies, you have several alternatives. An easy but moderately expensive solution (about \$350-\$400) is to get a microfloppy drive for the desktop computer or an external 5¼-inch drive for the portable. Manzana Systems' line of 3½-inch disk drives for desktop micros can read and write not only the standard 720-kB MS-DOS format but also the formats of some other portables such as the Hewlett-Pack-



Grid boasts models with every commercial flat-panel technology, including electroluminescence (shown).

Modular designs that can leave the disk drives behind are the only way to cut weight and size significantly.

ard Portable Plus.

The cheapest but most awkward transfer technique is to connect a null-modem cable (a cable crosswired to replace a pair of modems) between the two computers and use a communications program at 1200 bytes, or 9600 bits, per second (this is the most practical connection method for the Tandy 102 and 200).

Two mid-priced solutions are probably the most useful. White Crane Systems' Brooklyn Bridge (\$130) connects the two computers with a serial cable operating at 10,000 bytes per second; software running on both machines permits one computer to address the other's disk drives directly (the two drives on the portable become drives D: and E: to the desktop, for example). Converting disk formats then becomes a simple matter of copying from one disk drive to another. For more than two computers, Server Technology's EasyLAN (about \$100 per computer) can connect multiple desktop and portable computers together in a modest local-area network using standard serial ports; each machine can send and receive files on

whatever disk drives are available.

The main alternative to the IBM PC compatibles in the business world, the Apple Macintosh, does not adapt easily to portable form. Three companies—Colby, Dynamac, and Intelitec—are producing flat-screen Macs for travel, but all weigh over 15 pounds and are essentially ac-powered (although some can run briefly on batteries). Although the standard Macintosh includes some CMOS parts, a complete set of Mac chips is not available in CMOS; the traveling Macs mostly use standard Apple components except for screen and power supply. Since the Mac as sold by Apple is already fairly compact, the advantages of these traveling versions are not as clear as those of their IBM PC-compatible cousins.

Dynamac offers the cleanest and least cluttered component layout of the three, but has no place to store the mouse unless everything goes inside a carrying case.

What to buy? It all depends on what is most important to you. For note taking on the go, the Tandy 102 remains the best choice. Among IBM PC compatibles, choose the Toshiba 1100 Plus (preferably after a supertwist screen is available) for the most compact package and convenient operation in airplanes. The Zenith is better for poor lighting conditions when battery life is not crucial; NEC makes the keyboard easier if you can stand the bulk. Or wait a year and look at the new LCD screens with more pixels and better overall appearance than the present supertwist screens.

The future promises steady improvements in portables but few dramatic changes. Because our vision will not get keener or our hands smaller, overall physical size cannot shrink greatly; portables will mainly get thinner. More companies will adopt modular designs, because the only way to cut weight and size significantly is to leave the disk drives behind when you do not absolutely need them.

Perhaps the biggest change brought about by portables will be social. With portables we lose all excuses not to work, except while driving a car (passengers are expected to work). This, I suppose, is progress. □

Cary Lu is microcomputer editor of HIGH TECHNOLOGY.

For further information see RESOURCES, p. 65.

Canada

A great place to live.
A great place to invest.



Canada is open for business and eager to see your business ideas prosper. Our resources, energy, people and exchange rate can give you a competitive edge in the North American and global markets.

Canada welcomes entrepreneurs like you. If you are interested in moving to Canada to establish or purchase a business, or to invest, take the first step into a great new future by mailing the coupon today.



Please mail your information package on the Business Immigration Program and investment opportunities in Canada.

Name

Title

Address

Mail to: Canadian Consulate General, 1251 Avenue of the Americas
New York, NY. 10020-1175

Circle No. 20 on Reader Service Card.



External Affairs
Canada

Affaires extérieures
Canada

Canada

Industrial researchers have long known that there's much more to diamonds than good looks. Besides being the hardest substance known, diamond also exhibits a remarkable set of physical, chemical, and electrical properties: it is unmatched in transparency, for example, is an efficient conductor of heat and electricity, and is highly resistant to corrosion and radiation.

Now researchers in the U.S., Japan, and the Soviet Union are trying to put these properties to work in the form of ultrathin diamond films. Although most of the work is still in the precommercial stage, materials specialists say the near-term results could include sharper and more durable machine tools and abrasion-resistant data storage disks; eventually, the technology could also lead to power-

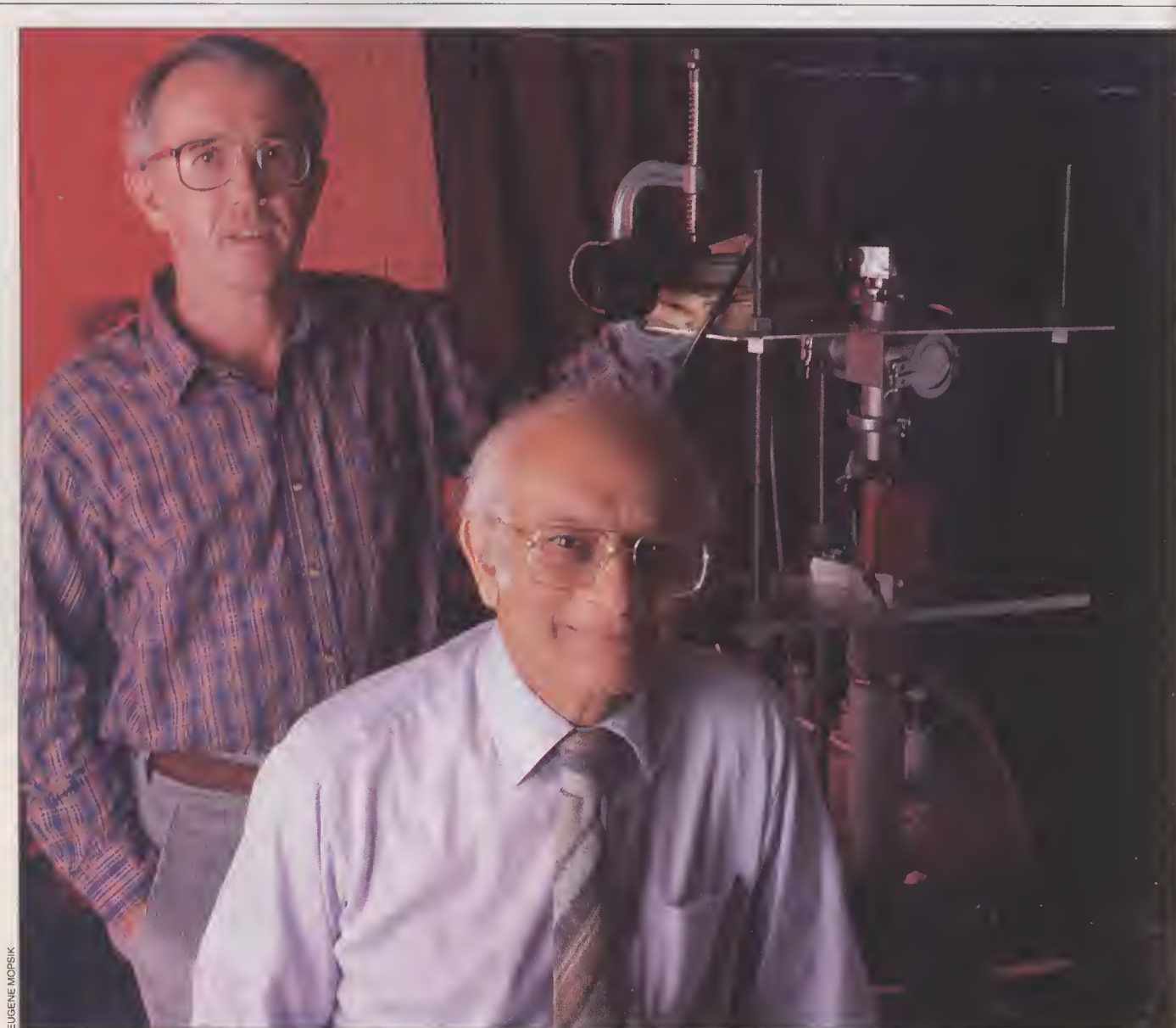
ful new transistors and higher-density computer chips.

The optimism arises from recent experiments at Pennsylvania State University, where researchers have duplicated diamond coatings first made in Japan and the Soviet Union. In the Penn State technique (which is only one of several diamond-film "recipes"), the object to be coated is exposed in a quartz tube to a plasma (a superhot mixture of ionized gases and electrons) formed by exposing methane gas, hydrogen, and argon to intense microwave radiation. Within an hour, the carbon atoms in the methane plate out as a diamond layer about one or two millionths of an inch thick.

The films are of more than academic interest. "We see a wide range of potential applications," says G. Leonard Baker, Jr.,

a partner in Sutter Hill Ventures (Palo Alto, Cal.); the firm is backing Crystallume (also of Palo Alto), a small start-up company that plans to market diamond-coated products such as cutting tools, computer disks, and aircraft windows. While each of these markets might be small to medium in size, says Baker, total sales could add up to "hundreds of millions or even several billion dollars" within a decade.

Those numbers have drawn several corporate heavyweights into a new consortium, organized by Penn State, that allows participants to share in generic diamond-film technology—for an annual fee of \$20,000. The group now includes Alcoa, Raytheon, Du Pont, GTE, AT&T Bell Labs, Bausch & Lomb, and Westinghouse; the latter company is now gearing



EUGENE MORSE

Penn State's Messier (left) and Roy use Russian vapor-deposition techniques to create diamond films from methane.

up to conduct diamond-film research for such applications as advanced optical systems and high-power semiconductor devices. And although IBM is still undecided about joining the group, a company source notes that Big Blue is looking "in a general way" at diamond films in the data storage area.

The task now is for U.S. researchers to catch up with the Japanese and the Russians, says Penn State physics professor Rustum Roy: "We're at least 10 years behind the Soviets and five years behind the Japanese" in diamond-film technology. Given the rising industrial and government interest in the technology, however—and the fact that U.S. researchers are using foreign experience as a sort of springboard—Roy predicts that "we'll catch up within two years."

RUSSIAN ALCHEMY. Until recently, only a few American researchers had tried to make the ultrathin films. They had labored for years but had been unable to produce coatings with all the properties of diamonds. U.S. scientists were thus skeptical about reports during the 1970s that investigators at Moscow's Institute of Physical Chemistry had made true diamond films via chemical vapor deposition (CVD)—a process by which a carbon vapor is deposited on a substrate. The claims "seemed almost like alchemy," says Russell Messier, associate professor of engineering science and mechanics at Penn State. The scoffing waned during the early 1980s, however, when Japan's National Institute for Research in Inorganic Materials (Ibaraki) repeated the Russian work.

The coatings are now made either by CVD techniques or by bombarding a substrate with high-velocity carbon ions, which then form a film. In the latter method, carbon ions may be generated from a hot carbon cathode or produced by "sputtering"—that is, knocked off a solid carbon block by a high-energy beam. Various ion-beam and sputtering methods are under study at the NASA Lewis Research Center in Cleveland.

Both types of techniques have generally yielded diamond-like rather than true diamond films. The diamond-like films are perfectly adequate for many applications, according to Bruce Banks, chief of the electrophysics office at NASA/Lewis. For example, they could be used to make abrasion- and corrosion-resistant computer disks, and infrared-transparent windows in aircraft that would stand up against pitting and scarring from raindrops at high speeds.

But for making semiconductors and other advanced electronic products, only the precise crystalline structure of a true diamond film will do; thus the focus on CVD, which can produce such films. What all the CVD methods have in common is the pyrolysis (breakdown by heat or radiation) of a hydrocarbon such as methane in the presence of the surface to be coated. These processes must avoid or minimize a frequent pitfall of diamond-coating methods: the co-deposition of graphite, a form of carbon that is much more common than diamond.

While CVD techniques for making diamond-like coatings were reported as far back as 1968, it wasn't until 1977 that Russian scientists devised a way to make true diamond films, with a minimum of graphite, by adding hydrogen to the methane before it decomposed. Since then, adding hydrogen has been a key element of various vapor deposition processes for diamond films. Although hydrogen's role in the process is still poorly understood, researchers speculate that hydrogen atoms prevent the creation of graphite-forming double bonds between the carbon atoms and promote the carbon-carbon single bonds typical of diamond.

SCALPELS AND TWEETERS. Among the most important developments in CVD are methods (based largely on the addition of hydrogen to the methane) that allow diamond to be deposited on a wide range of surfaces, including metals, silicon, and glass; early methods allowed deposition only on other diamonds. Crystallume president Thomas A. Schultz says his company plans to use the Penn State technology to make a variety of novel products, including cutting tools, knives, surgical scalpels, computer disks, and windows for planes and space-

DIAMONDS FIND NEW SETTINGS

*Ultrahard coatings could lead
to better cutting tools,
computer disks, and lasers*

BY GORDON GRAFF

craft; also on the docket are heat sinks and heat-resistant enclosures for high-temperature electronic equipment.

Schultz claims that Crystallume has also solved a problem that formerly bedeviled attempts to coat plastic magnetic disks with diamond: high deposition temperatures that would ordinarily melt plastics. "We've developed a lower-temperature coating system," he says, while declining to give details. Meanwhile, he's negotiating with "half a dozen Fortune 500 companies" on ventures involving both the production of finished OEM parts and the licensing of Crystallume's technology. The first Crystallume products—probably in the electronics area—are expected to reach the market during the first half of 1987, says Schultz.

Another company doing diamond-film work is Ovonc Synthetic Materials (Troy, Mich.), a subsidiary of Energy Conversion Devices. Ovonc president Julius J. Harwood notes that the firm is now developing its own CVD process and exploring several prospective electronics applications.

One diamond-coated product that is already on the market in the U.S. and abroad is a loudspeaker tweeter manufactured by Japan's Sony Corp. It consists of two layers of aluminum separated by a composite honeycomb structure; one of the aluminum layers is coated with diamond, which, according to a Sony spokesman, gives the unit greater rigidity and hence superior response to frequencies of up to 35 kilohertz. Even though the speaker's higher frequencies are well beyond the range of human hearing, he says, "our subjective listening tests indicate

that, for whatever reason, the unit sounds better" than conventional tweeters.

DIAMOND SEMICONDUCTORS? Research is also under way to tap the electrical characteristics of diamond films. For example, transistors made of diamonds, unlike conventional silicon-based devices, could handle high-power signals at the microwave frequencies used in earth-to-satellite links. Communications satellites using such transistors would be smaller, lighter, and more dependable than today's orbiters, which, according to Max N. Yoder at the Office of Naval Research, must rely on vacuum tubes to generate high-power microwave signals.

The Defense Department is also interested in diamond transistors because they are practically invulnerable to the nuclear radiation that might be encountered in "Star Wars"-type scenarios. In fact, the Strategic Defense Initiative Organization (SDIO) has announced a Crystalline Carbon Technology Initiative, which earmarks \$2.7 million for the first year of diamond-film studies at North Carolina State University (Raleigh), MIT, Penn State, and Research Triangle Institute (RTI) in Research Triangle Park, N.C.

Another military application in the works is diamond power transistors for generating intense ultraviolet laser beams that could aid in satellite-to-satellite communication, or be harnessed to destroy enemy missiles. Diamond-based semiconductors could also be fabricated into ultraviolet detectors for civilian and military space communications. And diamond-coated electronic sensors for automobile engines, under study by several Japanese companies, could function reliably in some of the hottest parts of the engine—next to the combustion chamber, for example, to monitor gas composition.

The only diamond-based electronic devices reported so far are Russian-made diodes (devices that rectify a current, or pass it in a single direction, but do not amplify it). They are made by doping natural diamonds through ion implantation, in which phosphorus and boron ions are shot at high velocities into the crystal surface. But ion implantation damages diamond surfaces, leading to inconsistent results.

Michael Geis, a research staff member at MIT's Lincoln Laboratory (Lexington, Mass.) thus hopes to use predoped single-crystal diamond, obtained from RTI, in an attempt to make semiconductor triodes (devices that amplify a current). Rather



Above: North Carolina State's Robert Davis hopes to produce less costly semiconductor-grade diamond by growing films on low-cost substrates such as nickel.

Left: Crystallume's Thomas A. Schultz holds a diamond-coated silicon wafer, which could be used to fabricate high-density IC chips. The company will begin offering several such products this year.

than firing ions into the substrate—which could damage the surface to the point that it becomes useless for this application—RTI will prepare predoped high-quality single-crystal diamond by adding the dopants to the film-growth mixture.

HIGH-DENSITY CHIPS.

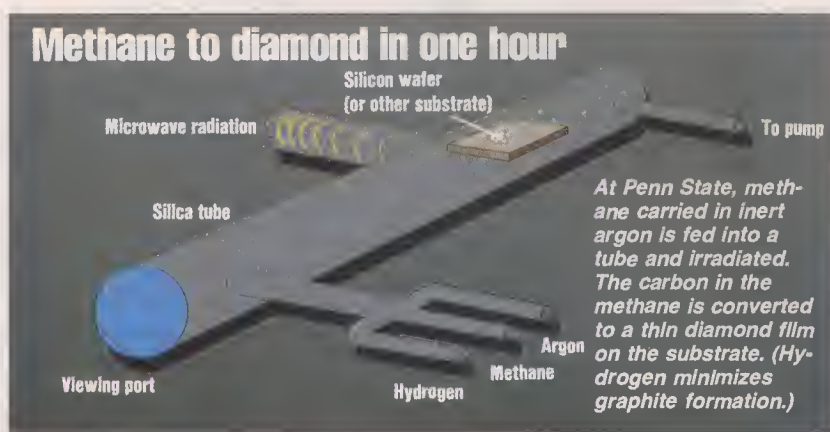
One of the most intensely sought goals of diamond researchers is an integrated circuit made of diamond rather than silicon. Since diamond's thermal conductivity is at least 10 times that of silicon, diamond semiconductor chips could (at least in theory) be placed closer together, allowing for perhaps an order-of-magnitude increase in circuit density over conventional devices. The closer spacing would also mean faster circuits, since electrons would spend less time traveling between chips.

Japan's Sumitomo Electric Industries reportedly has grown semiconductor-grade diamond films and will begin marketing devices for space and automotive applications within the next year. Several sources familiar with Sumitomo's work say the company's diamond films have been grown on other diamonds (instead of more economical metals and other materials); as a result, the company's devices, whenever they reach the market, will likely cost much more than ordinary silicon-based chips.

The first requirement for semiconductor-grade diamond is extremely high-quality material made from a single crystal that can be doped with impurities to enable it to carry a current. A group at North Carolina State, led by materials science professor Robert F. Davis, and an RTI group headed by Robert J. Markunas, are trying to grow such high-grade films within the SDIO program.

To improve the economics of potential electronic devices, researchers are trying to grow semiconductor-grade diamond films on inexpensive substrates such as silicon, ceramics, sapphire, or metals; since the substrates become part of the finished product, their cost is a critical economic factor. A particularly interesting substrate is nickel. The reason, according to North Carolina State's Davis, is that the metal has a crystalline structure "that is almost a perfect match" with diamond's, thus allowing good adhesion.

Davis and Markunas are using an unusual film deposition technique called remote-plasma CVD. In this process, hydro-



gen gas passes through a superhot plasma outside the deposition chamber, forming high-energy hydrogen atoms. Along with a mixture of methane and hydrogen, the atoms are pumped into the chamber, where all three reactants combine to plate out diamond on a substrate. The key advantage of remote-plasma CVD, says Davis, is that "it allows much more control of the decomposition of methane," since shutting off the supply of high-energy hydrogen atoms immediately stops the plating process; the result, he notes, is a more uniform product.

Even as researchers grapple with the problem of growing single-crystal diamond films on low-cost substrates, there are parallel efforts—at North Carolina State under Davis and at MIT under Geis—to fabricate finished devices using thin films of doped natural diamond. Since those films are not yet of high enough quality, researchers must content themselves with doped natural diamonds that are really too thick for the job. Geis says that a lot of his current work consists of grinding and etching these diamonds to the 1-micron thickness required for device applications. He notes that the starting diamonds are small enough to fit through the ring holes in looseleaf paper and typically cost about \$700, "so even if we could make a great device with them, it would be too expensive."

COST CUTTING. Economics, in fact, crops up repeatedly in discussions of the future of diamond-film products. The big question is whether advances in technology and economies of scale can trim production costs enough to make them mass-market items.

Some experts think so. In the semiconductor area, points out Yoder at the Office of Naval Research, today's starting material is expensive silane gas (a compound of silicon and hydrogen); by contrast, the starting material for diamond semiconductors would be methane or some other inexpensive hydrocarbon. Even allowing for more complex process-

ing requirements, he says that "if one goes into large-scale production, the basic costs of diamond technology should not be very different from those of silicon technology."

Of course, Yoder's underlying assumption is that the diamond deposition technology will be made more efficient. And as Penn State's Messier admits,

"there's still a lot of room for improvement" in diamond coating processes. Right now, he says, researchers at his institution and elsewhere are trying to decrease deposition temperatures and increase the deposition rate, and are seeking alternative technologies that would permit the coating of surfaces of a wider variety of sizes and shapes.

Messier declines to go into specifics about his latest efforts. But researchers at the Nippon Institute of Technology (Miyashiro, Japan) recently published details of an improved CVD process in which gaseous hydrocarbons such as methane are replaced by methanol, ethanol, acetone, and other oxygen- and nitrogen-containing organic liquids. They claim that the diamond deposition rate is at least 10 times that of methane-based techniques. Although no one understands why the liquids are apparently more efficient than the gases, some researchers speculate that it may be because they contain oxygen. Messier is now attempting to duplicate the Japanese process.

Despite such advances, however, few industry observers feel that a boom in diamond-coated products is imminent. Venture capitalist Baker likens the state of the technology to that of genetic engineering about 10 years ago. And as with genetically engineered products, he expects the new diamond-based devices to sell "for a big premium," particularly where high performance is needed.

Still, he's enthusiastic about prospects for diamond films and is encouraged by recent progress. "These are materials that have never existed before," he says, "and many of them had no apparent use when they were first announced. Now we hear almost every day about new applications."

Gordon Graff, a New York-based writer, is a former senior editor of HIGH TECHNOLOGY.

For further information see RESOURCES, p. 65.

North Carolina a great place for gro



Bountiful
harvests have
always been
a way of life in
our state.

Whether
you're growing
apples or new

technologies, our climate for business,
research and good living is ranked among
the very best in the country.

We've also broken new ground with
cultural and educational advancements.

For example, we were the first state to
fund an orchestra and an art collection.

N.C. Department of Commerce, Business/Industry Development Div., Suite 2210, 430 N. Salisbury St., Raleigh, NC 27611.

It has always been growing things.

And we were the first state to found a free residential school for the arts.

Also, our Research Triangle Park is the largest of its kind in the world, and one of America's top research centers.

All this may be why, by the year 2000, we're projected to be one of the five leading growth states in the nation.

That's important. But it's even more important that we're an excellent place to raise the most valuable resource of all:

Families.

Call, and we'll tell you why there's a growing interest in our state by companies all over the world. **North Carolina**

Write to us, or call this number: 919/733-4151.

Circle No. 16 on Reader Service Card.

CT SCANNERS SEEK OUT MANUFACTURING FLAWS

Cross-sectional profiles of the internal organs have become almost commonplace in today's arsenal of medical diagnostic tools. Now the x-ray technique behind these striking images—known as computed tomography, or CT—is turning up in a variety of industrial settings. Its mission: to probe the innards of materials and manufactured parts for cracks, voids, weaknesses, or foreign objects that elude conventional inspection tools.

So far, industrial use of CT inspection has been limited to such exotic items as rockets and nose cones. But future subjects include turbine blades for civilian aircraft, automobile engine castings, oil-drilling cores, and even bones in beef. "I see CT catching on in specific niches where improved safety or reliability justifies its high cost," says Edward Peters, a materials scientist at Arthur D. Little (Cambridge, Mass.). Peters believes that the increasing use of materials such as composites and ceramics, whose engineering properties are not entirely known, will encourage industry to adopt CT inspection of parts made from them.

The major problem with CT is its expense. Systems now cost typically \$1-10 million, and are not expected to get much cheaper in the next decade. Then there is the radiation; the dependence of CT equipment on high-energy x-rays "imposes some handling considerations that not every industry is ready for," says Paul A. Turton, vice-president of marketing at Scientific Measurement Systems (SMS) in Austin, Tex., one of a handful of companies offering industrial CT systems.

Because they need to examine thicker and denser objects than their medical counterparts, industrial CT units use more penetrating x-rays—with energies of up to 15 megaelectronvolts (MeV), versus 140 kiloelectronvolts (keV) for a typical medical CT. Several CT instruments, including one from SMS, contain in addition to an x-ray generator a gamma-ray emitter, typically a radioactive isotope of cobalt or iridium. Gamma rays scatter less than x-rays and so provide crisper pictures. On the other hand, commercial gamma-ray sources are less "bright"

than x-ray machines, so it takes longer to make an exposure.

The rays are channeled into a fanlike beam that can be as thin as a millimeter or as thick as an inch. Placed some distance away from the source is an array of detectors that transforms any transmitted radiation into an electric current. The current is translated into a digital signal, which is fed into a computer for image processing. Between the source and detector is the object being tested. For an ordinary x-ray picture, the object is held stationary while the beam passes through it. For the resulting two-dimensional portrayal of the object, features from many different layers are superimposed on one another, making interpretation difficult. Tomography (from the Greek *tomos*, or slice) exposes the object to the x-ray beam at many different angles; compiling the resulting image signals yields a cross-

X-rays reveal cracks, voids, and foreign particles in items ranging from car engines to sides of beef.

tional view that realistically depicts the spatial relationship of features inside the object.

Usually, the million or more exposures of a typical scan are made by moving the object through the beam with the source and detector held steady. In one unit, built for the Air Force by Advanced Research and Applications Corp. (ARACOR) of Sunnyvale, Cal., the object, such as a rocket section, is moved back and forth through the beam on a track. After each pass, it is turned a few degrees; after 180° of rotation, the image is constructed. The scan can be repeated at a different height by raising or lowering the object on an elevator platform.

Constructing an image is a mammoth computational task. The intensities of the pixels (picture elements) that ultimately form the final image are arrived at by

solving thousands or even millions of interdependent equations. One CT unit developed by Bio-Imaging Research (BIR) of Lincolnshire, Ill., for instance, performs as many as 200 million operations per second; up to eight processors can be linked for still higher speed.

The CT image resulting from all that number crunching reveals defects clearly enough to be seen without special training; interpreting conventional radiographic films, by contrast, is something of an art. And because the tomographic images are in digital form, they can be manipulated to heighten contrast so that some features stand out. In a welded joint of a steel pipe, for example, density can be graded on a color scale from blue (low density) to red (high density). Such color coding could help engineers quickly spot poorly welded areas that might be sources of failure. Similarly, air gaps or foreign particles in an engine casting could be highlighted in black or red. CT pictures can also be magnified or overlaid with other images to see if a part exactly matches a prototype.

The industrial use of tomography was pioneered by the military. One of the first such CT applications—the AF/ACTS (Air Force Advanced Computed Tomography System), sponsored by the materials laboratory of Ohio's Wright-Patterson Air Force Base—focused on quality control in the manufacture of MX missiles.

Under the AF/ACTS program, which began in 1981 and continues at a Sacramento facility of prime contractor Aerojet Strategic Propulsion, two tomographic units were built by ARACOR. One has an x-ray source producing up to 420 keV, and handles objects weighing up to one ton and as much as three feet thick. It profiles such objects as auxiliary motors, composite structures, and electronic systems.

The second unit, with x-ray energies as high as 15 MeV, can inspect loads as thick as eight feet and weighing up to 55 tons. It has been used recently to examine the inside of a fully loaded second-stage MX rocket motor. Inspectors of the rocket look for such things as voids or density variations inside the fuel (which could signal chemical changes) as well as separations between the fuel and the outer casing. Any of these problems could cause

by Gordon Graff

the missile to go astray after ignition.

There are other military and space applications as well. American Science and Engineering (AS&E) in Cambridge, Mass., is building six CT units for use in inspecting the Navy's submarine-launched Trident missiles. Two of the systems have already been completed, notes AS&E senior vice-president Richard Mastronardi. At NASA, two CT programs are under way. The Kennedy Space Flight Center in Cape Canaveral has a unit built by SMS that monitors components such as valves, turbine blades, rotors, and stators that are critical to flight safety and performance. And at the Marshall Space Flight Center in California, BIR is building a system to inspect new composite materials, rocket nozzles, and other components.

CT is entering the private sector, too, examining such products as turbine blades, truck tires, and piping in chemical and nuclear power plants. But the companies that supply CT equipment and services are tight-lipped about details, citing secrecy agreements with their clients. While most of these programs are in the research and development phase, a few have made it to the production floor.

At GM's Central Foundry division in Defiance, Ohio, for example, a tomography system made by SMS monitors engine block castings, tie rods, connecting rods, and pistons. The testing, which began last August, checks the newly manufactured parts for both size and quality. If dimensions start to stray from preset norms, the molds can be corrected before too many faulty components roll off the assembly line. Similarly, if cracks, voids, or inclusions are found in a sample, the reasons can be investigated before a whole batch of parts is ruined.

Meanwhile, General Electric is using CT to inspect the insides of aircraft engine turbine blades at its Madisonville, Ky., manufacturing facility. The blades are first viewed in the "digital fluoroscopy" mode, which essentially generates an ordinary x-ray picture on a CRT. If this reveals foreign objects or other defects, the part is examined in the CT mode, which creates cross-sectional profiles of features such as the radial walls and ribs.

CT's usefulness extends beyond manufacturing. Some oil companies, for example, use the technique to help decide where to drill. Cross-sectional x-ray images of core samples show the sizes, shapes, and distribution of gravel and pebbles—indicating where the sediment originated and furnishing important clues as to whether it might overlies petroleum deposits. Cracks in the cross-sectional core, for example, often serve as conduits for oil seeping up from below. In addition, says ADL's Peters, CT inspection has gen-



A jet-engine turbine blade (top) is partly hollow to permit air cooling; blockages could produce overheating and cause the part to fail. The red areas in the CT scan (bottom) indicate the presence of such blockages, which sometimes arise during casting.

erated "a lot of interest" in the food-processing industry; the x-ray systems can inspect beef, poultry, and fish, for example, to make sure that such products as hot dogs and frozen dinners do not wind up with hidden bones.

Improvements in computer hardware and software are extending the range of CT applications. In a technique called lam-

inography, for example, the computer can be instructed to zero in on an ultrathin layer (as little as two thousandths of an inch) of a multilayer structure. The result is not a cross section, as in conventional CT, but more like a view of each concentric layer of an onion on a flat surface. Laminography could be used to check the concentric layers of a rocket motor or several levels of multiple electronic circuits. It requires less data than conventional CT, and hence works several times faster.

Another enhancement being offered on some CT systems enlarges the cross-sectional image so that features down to a thousandth of an inch are visible. Getting such resolution requires an extremely narrow x-ray beam—about 20 microns across—along with unusually sensitive detectors. The Air Force is sponsoring development of such "micro-CT" to help in the study of structures of engineering ceramics, composites, and other advanced materials.

As useful as these refinements are, CT is not likely to be embraced as a routine industrial tool until several technical limitations are solved. One is the slowness of the process; it typically takes 15 minutes after the scan is complete for the computer to construct the image. Developers are trying to speed things up, however; one CT system that ARACOR is building for the Air Force uses refinements in image-processing software to produce a new image every 45 seconds, according to senior vice-president S. Thomas Workman.

Industry acceptance of CT will also hinge on reducing the labor needed in CT inspections, thereby cutting both cost and chance of error. "We're all looking for the day when we'll have automatic defect interpretation," says Workman. And GE has "been putting a lot of money in CT systems where computers will make the decisions," says David L. Hampson, a technology manager at GE's Aircraft Engine Business Group (Evendale, Ohio). Ideally, he explains, the process could be self-correcting. Once a defect is spotted—say, overdrilling by a laser beam—the computer would be programmed to order the production equipment to drill to the correct depth.

No matter how routine CT becomes, no one thinks it will ever be deployed to monitor paper clips, milk cartons, or other run-of-the-mill products. "To find new markets for CT, we're going to have to look for very expensive items to monitor," says ARACOR's Workman. "Fortunately," he adds, "there are a lot of expensive items out there." □

Gordon Graff, a New York-based writer, is a former senior editor of HIGH TECHNOLOGY.

THE BIG SCREEN COMES HOME

When wide-screen projection televisions were developed about 15 years ago, they promised to bring some of the appeal of the movie theater into the home. But there were problems: pictures were dim and fuzzy compared to direct-view TV, and the sets were too large and expensive to appeal to many homeowners. These problems have since been somewhat alleviated: smaller projection sets, better brightness and contrast, sharper images, and more affordable prices are boosting their popularity. At the same time, the availability of theater-like surround-sound processors is bringing the aural aspects of modern cinema into the living room.

All projection TVs basically follow the concept pioneered by Henry Kloss, chairman of Kloss Video (Waltham, Mass.). The image is formed in three picture tubes (one for each primary color), and then projected by lenses onto a screen. In front projection, the projection console sits on the floor in front of the screen, and requires an unobstructed light path. Rear-projection sets combine screen and projector in a single large cabinet, with mirrors that fold the light path so it can reach the necessary length. Projection televisions range from about \$2500 to as much as \$6000.

THE BIG PICTURE. Although large size is their appeal, projection sets now offer smaller-screen options. The Kloss Novabeam, for instance, formerly sold only with a 78-inch-diagonal screen, now comes in a 60-inch version. Other makers have concentrated on 40- and 45-inch sets, which, if less than cinematic in size, are more compatible with many home decors. On the other hand, viewers who want bigger-than-life pictures can get the 180-inch option on the Standard Reference Television from Infinity Systems (Chatsworth, Cal.).

Today's front projectors are also less obtrusive—rather than being stacked in a triangular pattern, the three projection tubes are arranged horizontally so the console is lower. Infinity sets even come

with a wood cover that doubles as a coffee table. In addition, most front projectors are equipped with picture-inverting controls that allow the console to be installed upside down on the ceiling.

A few rear-projection units have shrunk to a size barely larger than the wooden consoles of older direct-view sets. More mirrors are used to fold the light path several times within the cabinet, together with short-focus, aspheric lenses (with parabolic, hyperbolic, or other non-spherical surfaces) that both reduce projection distance and produce a sharper image. Until recently, aspheric lenses were too expensive because they had to be hand-ground—their complex surfaces could not be produced by automatic grinding machines, which are limited to flat or

Improved optics plus screens with higher contrast broaden the appeal of projection TV.

spherical shapes. However, aspheric lenses can now be mass-produced, thanks to high-precision molding techniques that deliver the necessary surface accuracy, as well as advances in plastics (notably acrylics) with the required combination of transparency, refractive index, bubble-free formation, and resistance to heat. The most dramatic combination of aspheric lenses and rear-projection mirrors is model KPR-36XBR from Sony (Park Ridge, N.J.), a 36-inch set with projection hardware concealed in a slim pedestal instead of the usual cabinet.

Early projection sets gained picture size at the expense of appearing dim and washed out, producing a usable image only in a room as dark as a movie theater. But today's brightest projection systems, notably the Pioneer SD-P40 and Kloss Novabeam 100, can be viewed in normal room lighting. One method being used to improve brightness is by generating a brighter phosphor image on the inside of the projector's three color tubes. As in a conventional color television picture tube,

the phosphor coating produces the picture when it is electrically stimulated by a bombardment of electrons. While a brighter phosphor image will produce a brighter projected image, the more intense electron beam also generates additional heat, which may warp the phosphor and thereby distort the image. To remedy this, Pioneer Electronics (Long Beach, Cal.) and other manufacturers cover the phosphor tube face with an encapsulated liquid that serves as both a focusing lens and a coolant to dissipate heat.

Kloss takes a different approach. Whereas other projection units use refractive main lenses mounted outside the tubes, Kloss employs a deeply curved mirror lens built into its Novatron tubes. Henry Kloss explains that such a reflecting lens inherently produces less distortion than a refracting type. Novatron lenses are designed to be "faster" (transmit more light), projecting a brighter picture to the screen without resorting to a brighter phosphor image, says Kloss.

Another approach to improving picture quality is to improve the contrast provided by the screen. The contrast of any TV image is limited by the density of its black areas: at best, black parts of an image will appear only as dark as the screen when switched off. To make projection screens darker, many companies now apply "lenticular" surfaces, which are coated with tiny cylindrical plastic lenses that scatter any room light striking the screen, deflecting it away from the main optical path so the ambient light does not wash out the picture.

So far, Pioneer's rear-projection model SDP-40 has the most advanced lenticular design, with a coating on both the front and rear of the screen. The front coating simply diffuses light like other lenticular screens. However, the tiny lenses coating the rear of the screen are specially shaped to bend the light coming from red and blue projectors, which are slightly off-center, toward the front of the screen. (Light from the green projector, which is centered between the other two, already hits the screen head on.) This eliminates the slight color shift that occurs when a viewer moves to the left or right, putting him more directly in line with one of the outside projector tubes.

by Peter W. Mitchell



Image sharpness has been improved with aspherical lenses. But even with better lenses, an originally fuzzy image looks even fuzzier when enlarged on screen. To minimize the graininess or "snow" that may result from a weak or degraded television signal, or from the inherently grainy surface of videotape, Kloss uses a detail-enhancing circuit licensed from Faroudja Laboratories (Sunnyvale, Cal.). The circuit singles out transitions in the strength of the video signal that correspond to real image details and emphasizes them. Smaller transitions—those created by snow or grain—are ignored by the circuit. The result is a visibly crisper, apparently more detailed image.

A new alternative in large-screen television is conventional sets with bigger picture tubes. Despite advances in projection televisions, they will never match the contrast and color intensity of direct-view TVs because picture tubes are inherently darker than screens. Also, projection lenses inherently reflect or absorb some of the light, dulling the image. Mitsubishi Electric (Cypress, Cal.) leads in large-screen, direct-view televisions with its 35-inch set that boasts more than 100 pounds of glass in its picture tube. In the past,

such large tubes had a tendency to implode—since they are vacuum tubes, they succumb to atmospheric pressure if the screen surface is too large. Mitsubishi, however, uses heavy glass walls and a metal supporting strap to reinforce the tube. Other manufacturers are developing large direct-view sets, with screen sizes ranging from 30 to 45 inches. Their major drawback, of course, is weight—up to 300 pounds.

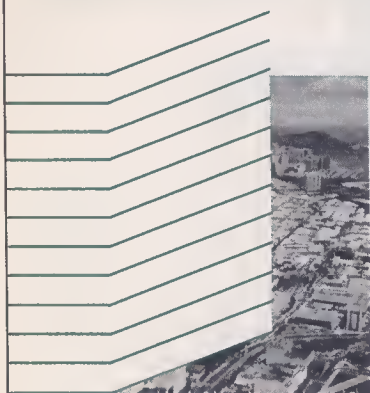
HEARING THE BIG SOUND. Since audio is an integral part of the moviegoing experience, surround-sound processors for the home are being developed to complement the big picture of projection sets. Home processors use the same surround data that is encoded into soundtracks for theaters. The processor, following the encoded instructions, distributes the sound signal to the appropriate channels to provide surround sound via speakers at the sides and rear of the room, creating spatial effects like airplane flyovers. In addition, the encoded data may be used for a center-front channel, so screen sounds such as dialogue seem to come from the picture.

In most cases, surround-sound processors are separate audio components that must be fed by the TV's receiver or video cassette recorder. They differ widely in design and features, ranging from about \$350 for models like the SD-2 from Audionics (Heber City, Utah), which lacks a center dialogue channel, to \$700 and up for models like the Sony SDP-505ES, which includes a center dialogue channel, a separate 16-watt amplifier to drive the rear speakers, and decoding logic for three types of surround encoding. (Some processors, for example, may decode only Dolby MP Surround data, and therefore wouldn't work on soundtracks using other methods of surround encoding.) NEC Home Electronics (Wood Dale, Ill.) offers a Dolby surround decoder bundled into its AVR-700 audio/video receiver, which also features AM/FM tuning and four channels of amplification.

The best sound enhancement comes from processors that include signal steering logic, namely the 3601 from Fosgate (Heber City, Ut.), model 720 from Surround Sound (Marina del Rey, Cal.), and HTS-5000 from Shure Brothers (Evanston, Ill.). In systems without such a circuit, surround signals intended only for the rear speakers may bleed into the front channel, confusing the direction of the sound, says Robert Popham, Fosgate technical service manager. Steering logic imitates the complex logic of a theater sound processor, automatically monitoring circuits and adjusting the signals in its four channels (left, right, center, and surround). For instance, during dialogue it may momentarily increase the signal to the center-front channel, particularly if output from rear speakers is high enough to obscure voices.

COMING ATTRACTIONS. So far, the combination of surround sound and wide-screen television is not widely available. Only Infinity's Standard Reference Television offers both in a single package, although Kloss is expected to announce a new model that also incorporates surround decoding. Other manufacturers are watching the market, but currently are concentrating on surround-sound processors as outboard modules. R. Greg Kalsow, manager of product planning for Pioneer, predicts that all stereo audio receivers will have

Hawaii: Islands of Opportunity



HAWAII WORKS is an economic development program of the Chamber of Commerce of Hawaii and the State of Hawaii

Thinking of expanding or relocating your business? We'll give you all the reasons why you should consider Hawaii.

Clip and send the coupon for your FREE copy of our booklet "Hawaii: Islands of Opportunity" to:

Alan S. Konishi
HAWAII WORKS
Department HT
P.O. Box 4089
Honolulu, Hawaii 96813
(808) 531-4111

Please send me a free copy of the booklet, "Hawaii: Islands of Opportunity"

Name _____ Title _____

Company Name _____

Type of Business _____

Address _____

Phone: () _____



HT

Circle No. 17 on Reader Service Card.

We are pleased to announce that

Thomas I. Unterberg

has joined our firm as head of domestic and international technology investment banking

with

A. Robert Towbin

as co-head of the operation

Shearson Lehman Brothers Inc.

February 9, 1987

CONSUMER TECHNOLOGY

surround-sound capability by year's end.

Capitalizing on digital processing of video signals, projection television may find further improvement in picture quality. For instance, Toshiba (Wayne, N.J.), Hitachi (Compton, Cal.), Panasonic (Secaucus, N.J.), and other manufacturers will soon introduce "noninterlace" televisions that eliminate visible horizontal scan lines—an innovation that applies to projection as well as direct-view television. A standard TV picture consists of about 500 scan lines, each "drawn" as the electron gun sweeps from left to right across the phosphor before dropping down to draw the next scan. Rather than running in sequence, the scans are transmitted in two equal fields that, when in-

Surround sound completes the home theater by recreating the audio effects of cinema.

terlaced, form a complete picture on the screen. Noninterlace scanning circuits store incoming fields in computer memory, and average each scan line point by point with the corresponding line in the other field. When an image is then displayed on the screen, averaged lines are laid between received lines. In effect, this doubles the number of scans, generating a smoother-textured display.

Home video won't soon replace the modern movie theater, which, for example, has a wide screen with a 2:1 aspect ratio (being twice as wide as it is high). Nevertheless, the improvements in projection TV and surround sound, together with the growing availability of movies from cable and satellite television and video cassette recorders, will probably encourage the home-theater trend already under way. Last year, about 304,000 projection sets were sold in the U.S., a 14% increase over 1985, reports the Consumer Electronics Group of the Electronics Industry Association (Washington, D.C.). The trade group forecasts that 1987 sales will top 360,000, a jump of more than 18%. □

Peter W. Mitchell is a recording and product design engineer who writes frequently about audio, video, and computers.

In the new FLANDERS EXPO site,
Ghent, Belgium.

hi-tech burgers in flanders?

The international trade fair
for new technologies.



**flanders
technology
international**

May 11 through 17, 1987,
from 9.30 a.m. to 6 p.m. daily.

May 11, 12, 13 and 14 : science professionals and trade only.

Hi-tech burgers in Flanders ?
Who knows ! For if it's world news and hi-tech, you'll certainly find it at Flanders Technology International '87. The only technology fair to apply such strict selection criteria, FTI brings you all the latest technological innovations. And nothing but. For biotech, micro-electronics, new materials and applied technologies.

Further information :

Hotel and flight reservation, tourist information and car rental :

FLANDERS TRAVEL, Mrs. S. Van Acker,
int'l + 32/3/232.99.34

General info on the trade fair :

Secretariat FTI
int'l + 32/91/22.60.31

Company visits :

Government of Flanders, Mrs. J. Mercken
int'l + 32/2/218.12.10

Seminars :

K. VIV (Royal Society of Flemish Engineers),
Mrs. R. Peys
int'l + 32/3/216.09.96

1

9

8

7

Circle No. 13 on Reader Service Card.

IMS 7/21

CERAMIC TURBINES FOR CARS COULD WIND UP ON PLANES

New types of ceramics, many of them synthesized in the laboratory, are showing promise as replacements for metals in the engines of the future. The initial research on all-ceramic engines has focused on automobiles, and so far ceramics have shown themselves capable of performing better than metals at the high temperatures necessary for the most efficient use of fuel. However, many engineers suspect that the high cost of specialized ceramics will put such engines beyond the range of Detroit and the average motorist. Ironically, the auto-oriented R&D seems most likely to provide ceramic engines for the aviation industry, whose costing structure can more easily absorb the elevated prices of ceramic components.

Even the best metal engines—those made from exotic superalloys like Inconel or Astroloy—cannot withstand temperatures above about 2000° F. That falls far short of the 3500–4500° F range at which all fuel elements oxidize totally and efficiently. Metallurgists forecast that future improvements in alloys will be incremental at best, and even then extremely costly. By contrast, lightweight ceramics such as silicon carbide do not deteriorate even at 3500° F. Although mass production of high-quality ceramics has yet to come, small-scale applications now being tested show encouraging results.

Ceramics have a range of properties attractive to engine makers. Extremely hard by virtue of complex crystalline structures, they are currently used to grind the superalloys that they may soon replace. Unlike most metals or organic compounds, ceramics are chemically inert, and hence corrosion-resistant. Many also have very low rates of thermal expansion, and maintain their physical properties at high temperatures—a combination that improves their ability to work inside hot-burning engines.

Certain ceramics possess properties that make them ideal for specific uses. Synthetic silicon nitride, for example, does not lose bulk in the firing process; hence, it can be molded to close tolerances without requiring later machining. The strength of sintered silicon carbide varies

only slightly as its temperature increases to a maximum of about 2500° F; this makes it a good structural material for combustion chambers. Because they combine extremely low thermal expansion and high thermal conductivity, aluminum silicate and lithium aluminum silicate are used for regenerator disks, which preserve energy by using the heat of combustion to preheat air coming into the engine. Zirconia behaves in the opposite way: with thermal expansion almost as high as that of metals, and thermal conductivity low enough to classify it as an excellent insulator, this ceramic is ideal for coatings, rings, and seals.

These monolithic materials have drawbacks, however, most notably brittleness and lack of malleability. As a result, they are being rapidly superseded by composite ceramics, whose structure of fibers inside a matrix ensures durability, toughness, and strong resistance to forces that tend to stretch it. A matrix of barium magnesium aluminum silicate that contains fibers of silicon carbide, for example, has high strength and increased fracture toughness up to about 2500° F.



The Allison AGT 100, a mostly ceramic twin-shaft turbine, was designed for easy linkage to an auto transmission.

Silicon carbide fibers in a matrix of either silicon carbide or a mixture of alumina, silica, and boria provide fracture toughness at higher temperatures. Ceramic composites will not match superalloys for toughness, warns James MacBeth, market development manager for Sohio (Niagara Falls, N.Y.). But future combinations of fiber and matrix, along with components redesigned to take advan-

tage of the materials' unique properties, will make the composites fully competitive with metals.

The promise of compounds for aero engines goes way back. Some manufacturers of aircraft engines knew of ceramics' potential in the '60s, as a result of using them in cutting tools. But according to Dan Kreiner, project engineer for power systems at Garrett Turbine Engine Co. (Phoenix), they regarded the cost of exploring that potential as too high for any single company. Then in the '70s, the Department of Energy (DOE) offered a useful, if indirect, means of carrying out the development—by studying the use of ceramics for automobile engines.

The first program, Ceramics Applications in Turbine Engines, begun in 1976, led to the \$120 million Advanced Gas Turbine (AGT) project, launched in 1979. This teamed Garrett with Ford Motor and teamed Allison Turbine Engines (Indianapolis), another company that had a strong interest in aero engines, with its GM sister company, Pontiac. AGT's goal was to develop technology for an affordable mass-produced engine that could run 30% more efficiently than existing engines, on a variety of fuels such as propane, diesel, or kerosene, and still meet federal emission standards. DOE's new \$50 million Advanced Turbine Technology Applications Program will use the AGT engine to develop production-standard ceramic technology.

The continuously burning gas turbine engine can burn almost anything from powdered coal to 80-proof tequila. But the new ceramic advanced gas turbine offers significant advantages over its metal predecessor in terms of fuel efficiency. The 100-horsepower, single-shaft Garrett AGT 101, for example, uses a gas regenerator to capture heat in the exhaust gas, which then heats the incoming compressed air prior to combustion. The net result: higher temperatures and more complete oxidation of fuel.

The AGT 101 started out as a metal engine, to prove the design concept. Ceramic parts were gradually added, enabling engineers to calculate the stresses and pressures on individual components, until it became the world's first all-ceramic engine. In its final configuration, the AGT

by Mark Patiky

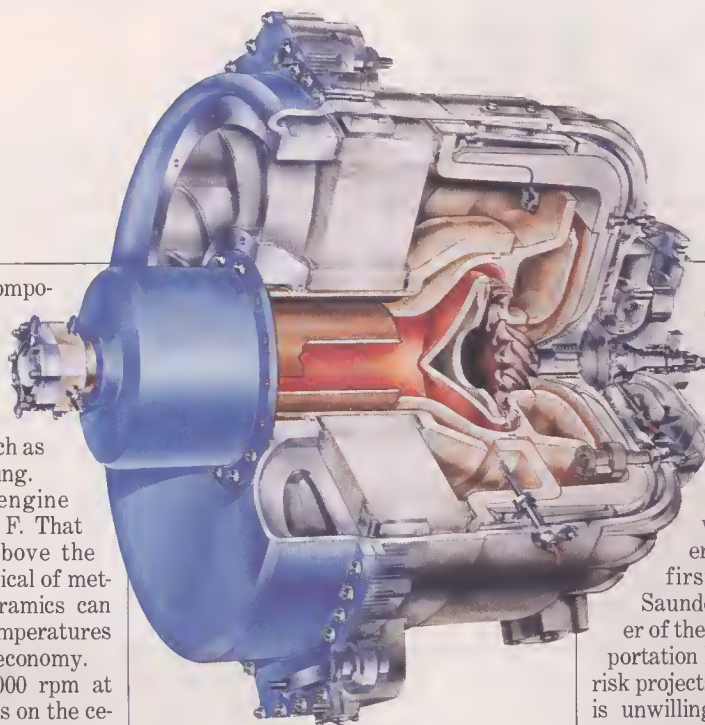
101 consists of 60 ceramic components, of which 11, including the turbine, are major structural parts. Six domestic and foreign suppliers have developed production techniques for the components, such as injection molding and slip casting.

In tests last year, the engine achieved 70,000 rpm at 2100° F. That combination, comfortably above the 60,000 rpm at 1600–1700° F typical of metal engines, suggests that ceramics can permit the high operating temperatures needed for large gains in fuel economy.

The ultimate goal of 100,000 rpm at 2500° F will put major demands on the ceramic turbine rotor. At maximum output, when its tips reach speeds of 1500 mph, the rotor will undergo huge thermal, centrifugal, gas-pressure, and vibratory stresses. But on the basis of nearly 100 hours of testing, Garrett engineers believe the engine can reach that goal late this year, and thus prove that a small gas turbine can reach the high turbine speeds at elevated temperatures necessary to make it fuel-efficient while producing low emissions. The major hurdles are durability and cost-effective mass production.

Allison's AGT 100, a twin-shaft design, has progressed less rapidly. It has achieved high temperatures and high speeds independently, but has had limited success with simultaneous speed and temperature. The problem stems from inconsistencies in the structure of the engine's ceramics, caused by difficulties in molding and forming complex shapes. Such inconsistencies can create areas of stress that weaken components. Garrett's experience with the AGT 101 has shown that a concentric design, whose major parts are circular, minimizes that effect. Allison's twin-shaft engine does not allow for circular parts, but company engineers are trying to overcome the problem by using more homogeneous ceramics and simplifying the designs of components.

The main difficulty facing the overall DOE program, however, is the automobile industry's skepticism that all-ceramic engines will fulfill the motoring public's requirements at an affordable price. GM's head of research, Charles Amman, points out that Chrysler, GM, and Ford have all



The world's first all-ceramic engine, Garrett's AGT 101, has demonstrated it can operate at the high temperatures and speeds necessary for fuel economy.

considered the gas turbine engine and then dropped it. Among the big three, only Ford is actively pursuing any type of ceramic engine—the adiabatic diesel concept, which involves high-temperature ceramic materials. By eliminating the water jacket, the adiabatic diesel engine preserves heat energy otherwise lost in cooling—a process that accounts for major fuel penalties, says Walter Wade, Ford's manager of engine research. But reducing these cooling losses to zero would cause cylinder walls to heat up to more than 1600° F—temperatures at which a conventional engine would not survive. Wade therefore concludes that the key to adiabatic diesel efficiency is to use high-temperature ceramic materials. Such an engine, he speculates, could theoretically boost fuel economy by 45%.

Even that prospect, combined with the ultimate likelihood of increases in oil prices, fails to convince engineers and analysts that the ceramic engine has a future in the automobile business. It is economic reality and not technological advance, that decides feasibility. An engine that is extremely expensive will find no consumer appeal, despite its ultimate efficiency. If the ceramic engine is to be competitive, argues Wade, its finished mass-produced ceramic components must cost no more than about \$3 per pound. With current rates between \$50 and \$200 per

pound, there are obviously challenges ahead.

The feeling in the automobile industry, says GM's Amman, is that there are more practical ways to achieve the energy-saving goals set for the automotive gas turbine engine. So why is the department of Energy funding the project in the first place? According to Saunders Kramer, program manager of the department's Office of Transportation Program, DOE feels that high-risk projects—those that private industry is unwilling to pursue—should receive government funding. In the end, explains Kramer, industry will profit from the development of byproducts that may never have become available without government encouragement. Certainly, we would not have seen high-quality production ceramics in 1987 were it not for the AGT project.

In fact, motoring's loss will probably be aviation's gain. As far as the aviation industry is concerned, the ceramic gas turbine will have immediate and significant impact. The ability to generate high-temperature gases not only guarantees efficient combustion and fuel economy but also provides significant increases in exhaust thrust—a factor meaningless for automobiles but useful for airplanes.

Thus, even if the ceramic automobile engine fails to materialize in the short run, researchers involved in the AGT project insist that the R&D effort will inevitably produce a far more efficient aircraft propulsion system.

Certainly, the economics are far more favorable. Aircraft engines are typically produced in low volume at high prices, allowing the elevated cost of ceramic components to be easily absorbed. According to Garrett's figures, an automobile engine costs just \$3 per horsepower, while a jet engine costs \$250 per horsepower, because of the far finer engineering tolerances required. Hence, materials costs represent a much lower fraction of aeronautical costs. In addition, the thrust increases possible in a ceramic jet engine mean a lot more power

ONE STATE GETS YOU 48.

Why does Oklahoma offer such a vantage point for distributing products, services and information to the continental U.S. and beyond? Companies like Fleming Foods, Armstrong World Industries, Thrifty Car Rental and Uniroyal Goodrich know why. They've discovered Oklahoma's central location. Where trucking in and out on interstates, I-35, I-40 and I-44 means loads can arrive at both coasts or either border in only two days. You can ship by rail in 6 days. Or by air in less than 4 hours. You can also ship your goods by barge to worldwide ports of call on the McClellan-Kerr Arkansas River Navigation System. More and more businesses are realizing greater savings by strategically locating in the middle of the country, where phone communication, on-line data processing and reservations handling are really cost efficient. Location is one of many important reasons why so many businesses are discovering Oklahoma. You should too. Call Don Paulsen, Executive Director, Oklahoma Department of Commerce at 1-800-443-OKLA for the facts on how easy it is to get products and information moving from the southwest's State of Excellence to the rest of the world.



Call toll-free: 1-800-443-OKLA
In Oklahoma call: 405-843-9770
6601 Broadway Extension, Suite 209
Oklahoma City, OK 73116-8214
Circle No. 12 on Reader Service Card.

MILITARY/AEROSPACE TECHNOLOGY

for the money. Garrett engineers thus forecast that ceramic engines will be lofting planes within 15 years.

Garrett and Allison have indicated that they will forge ahead in the aviation arena once the AGT contract is completed in 1991. However, the two companies are reluctant to discuss their plans in detail, because AGT remains ostensibly a project to develop ceramic automobile engines; too obvious a linkage between the project and the aeronautical industry might lead to awkward questions from automobile lobbies in Washington.

Garrett has, however, indicated its initial target after completing the AGT contract: using the AGT technology to design an aircraft engine that meets all the FAA's certification requirements. The major challenge will be to ensure the ceramic

R&D on ceramic auto engines will produce a more efficient aircraft propulsion system.

engine's durability and reliability. While appreciably better than metals at withstanding the combination of high temperature and high speed, ceramics are not as tough as superalloys. So the possibility cannot be dismissed that, say, a bird might demolish a ceramic engine by flying into it. Thus the engine will undergo the FAA's standard bird-injection tests, which mandate that it maintain 70% power after dead 4-pound and 12-pound birds have been hurled into it at speeds of up to 250 knots. The engine and its major components will also have to prove their reliability over a wide range of temperatures and environmental conditions and undergo rigorous altitude tests.

According to Kreiner, Garrett predicts that an engine incorporating the design features and ceramic materials available when the company considers the design in 1991 and beyond will pass the FAA tests. At that point, the company expects to seek support for joint development, either with Allison or with such industry giants as GE or Pratt & Whitney, which have closely monitored the AGT project. □

Mark Patiky is a freelance aviation journalist based in the Washington, D.C., area.

The world's fastest digital integrated circuit, a gallium arsenide (GaAs) chip that runs at a clock rate of 18 gigahertz (GHz), or 18 billion cycles per second has been built by Hughes Aircraft Company scientists. The ultra high-speed circuit operates as a divide-by-two frequency counter and is five times faster than currently available GaAs integrated circuits and ten times faster than commercial silicon circuits. Fastest frequency reported previously for static frequency dividers was 13 GHz for a laboratory device requiring cryogenic temperatures; the Hughes circuit operates at room temperature. Operation of digital circuits at multi-GHz frequencies opens new areas of digital communications and signal processing, promising better noise immunity, a wider range of functions, and less complexity than their analog counterparts. Applications are foreseen in fiber optic communication links, supercomputers, advanced radars, and satellite communications.

Ships at sea will be able to determine their positions via satellite. A maritime navigational system is one of the new services proposed for the existing system of Marisat satellites, launched in 1976. For the past 4 years, the trio of Marisats has been providing telecommunications services for the International Maritime Satellite Organization (INMARSAT), a cooperative of 47 countries that operate a worldwide system for maritime communications. Leases with INMARSAT have been renewed for three years by Comsat General Corporation, owner of the satellites, enabling the Hughes-built satellites to continue providing communications services to the military, shipping, and offshore industries.

A unique computerized visual system helps military forces simulate battlefield terrain. The system provides unusual realism and flexibility to help with a wide range of training and mission planning requirements. It can generate lifelike three-dimensional scenes from a computer database created with aerial photography. Pilots can use the system for nap-of-the-earth flight training, even to the point of seeing simulated radar and infrared displays. The Hughes system also can be used for intelligence analysis and team tactics training.

A night vision system for helicopters significantly reduces pilot workload by eliminating wasted movements, simplifying controls, and providing excellent video images and object detection in reduced visibility. The Hughes Night Vision System (HNVS) is a low-cost, forward-looking infrared (FLIR) system that provides a pilot with automatic tracking and digital video processing. It superimposes FLIR video, flight symbology, and navigational data on a single display, which can be mounted on the flight panel or in a helmet visor. The helmet visor display projects a FLIR image onto a biocular holographic combiner on a see-through visor. A helmet linkage, which moves the FLIR as the pilot's head moves, reduces the pilot's workload further and improves flight safety.

Hughes Missile Systems Group, in Canoga Park, California, an attractive suburb of Los Angeles, is advancing every phase of research, development, and manufacturing technology as it applies to tactical guided missile systems and strategic defense. Opportunities for engineers and scientists are in analog/digital circuit design, software engineering; high-voltage power supply design; microwave process, transmitter and radome design; electro-optical design; IR imaging sensors; focal plane arrays; quality assurance engineering; operations analysis; mechanical engineering; and production design and systems engineering. Send resume to Hughes Missile Systems, Engineering Employment, Dept. S2, 8433 Fallbrook Ave., Canoga Park, CA 91304. Equal opportunity employer. U.S. citizenship required.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

TURNING TELEVISION INTO A BUSINESS TOOL

A growing number of corporations are changing the way they do business by using a tried and true technology—television—in a range of innovative applications. Business television enables companies to market new products, train their staffs, and keep employees, stockholders, and customers apprised of corporate activities at a level of efficiency not previously possible. Television has been around for decades, but its widespread application in private business became cost-effective only a few years ago with the advent of new satellite technology.

By using business TV, companies need no longer send out videotapes en masse, underwrite expensive marketing road shows, or bombard branch offices with reams of memos and training documents. Instead, they can establish their own TV networks and produce their own business-oriented shows, which they can broadcast via satellite to various receiving sites; or they can tap into private business networks to both broadcast and receive a wide range of business programming.

One optional feature that makes business TV especially attractive to many companies is the ability to provide two-way audio along with one-way video broadcasts. So, for example, when the CEO goes on the air to announce a new corporate development that could affect stock prices, listeners can call in questions and get an immediate response.

Establishing in-house TV operations can be an expensive proposition, however. A full-fledged studio, along with satellite transmission and reception facilities, can cost millions of dollars. In addition, leasing satellite time for broadcasts can run from \$500 to \$700 per hour. But even with these costs, a growing number of companies are finding that the consequent reductions in travel expenses, postage, and videotape dubbing services can result in relatively rapid system payback.

One company realizing such benefits is A. L. Williams and Associates (Atlanta), a marketer of term life insurance and mutual funds that runs its own corporate TV network (ALTV). Now broadcasting train-

ing and motivational programs to 800 regional offices—independent contractors of A. L. Williams—about 40 hours a month, ALTV has reduced the company's printing bills by 25%, saving an estimated \$10,000 monthly. Even greater savings have been realized through the complete elimination of videotape dubbing and shipping expenses, which previously cost the company about \$20,000 a month.

"We expect to pay the whole thing off in three years," says Dan McConnell, director of education and training. "Our capital costs for the network were about \$4.8 million, but the monthly revenues from our independent contractor sites [each pays \$200 per month for the service] carries those costs and covers monthly operating expenses."

Al Maggio, television production manager at the Computerland Corp. (Hayward, Cal.), reports similar savings with CLND, a TV network that not only broadcasts corporate-sponsored training programs to the computer retailer's franchises, but also sells time to vendors

Firms can establish their own satellite TV operations, or broadcast and receive programs via other networks.

wanting to tout their products to the stores. Vendors sponsor programs about their products both as training vehicles for salespeople and as customer information tools.

Computerland previously used videotapes for these purposes, which required a staff of 10 and a monthly tape-duplication bill of \$10,000. Thanks to the TV network, both overhead costs and staff requirements have been cut in half. In addition, says Maggio, vendors are more inclined to sponsor a TV show than a videotape production because they can get instant feedback about the size of their audience. Vendors also appreciate the fact that producing a one-hour TV show costs only \$10,000, compared to the

roughly \$20,000 needed to produce a half-hour videotape.

While such hard-dollar savings are important, it is the ancillary benefits of satellite TV networks that attract some firms, according to Susan Irwin, president of Irwin Communications (Washington, D.C.), a consulting firm specializing in satellite services and network implementation. "Improved communications," she points out, "can ultimately lead to more productivity and more profit." Consider Hewlett-Packard, which pioneered the corporate TV network concept. The company ran its first satellite conference in 1981 to introduce a product to HP sales staffs and other interested parties at the company's sites around the country. Marika Ruomet, TV network manager for HP, says that on that very first "tour" the company slashed its product-introduction costs in half. "But that figure stopped being of concern after the first teleconference, when we found out how effective the medium was for transmitting complete and timely information. It's just a better way of doing things."

Hewlett-Packard now has 92 receiving sites, called downlinks, in its U.S. network. Each downlink has a satellite dish (to receive the programming that is bounced off a satellite transponder), a signal amplifier, and a receiver that enables channel switching between the programs handled by each transponder (a satellite has up to 24 transponders). The major expense companies incur with business TV is the capital costs of buying and installing the necessary equipment. These costs have dropped significantly, however, thanks to the availability of a high-frequency transmission band.

Traditionally, TV broadcasts use a microwave frequency signal of 4.5-7 gigahertz, known as the C-band. Because the C-band is also allocated for transmission of terrestrial communications, C-band broadcasts from satellites can suffer from interference problems in congested locations such as urban areas.

In the last two years a new band has been established that is reserved for satellite communications and thus does not have the interference drawback. This "Ku-band," operating at 12-14 gigahertz, also allows the use of less expensive

by Sam Diamond

equipment at the receiving earth stations. C-band receiving satellite dishes measure about 4 meters in diameter and cost approximately \$12,000, but Ku-band dishes are about half that size and price.

Broadcast origination, at sites called uplinks, is also cheaper for Ku-band than for C-band, again because the dishes are smaller and less expensive. In addition to straight broadcasting, the uplink sites may perform encryption, or the scrambling of the signal, to prevent unauthorized viewing of the program—a key concern for some proprietary business transmissions. A decoder is then necessary to view the program at the downlink end. This function, however, is independent of the band used for broadcasting.

Mainly because of the Ku-band, the number of business TV networks installed has grown about 60% per year since 1982, and the number of downlinks has either doubled or tripled each year, says Elliot Gold, publisher of *Telespan's Business TV*. Gold estimates that at the end of 1986 as many as 7000 business TV downlinks were installed, and that by the end of this year there will be a total of 13,000. Meanwhile, the number of events broadcast has also grown dramatically from about 50 conferences in 1980 (each going to an average of 20 locations) to roughly 500 conferences in 1986 (each to an average of 50 sites), according to David Green, vice-president of sales and marketing for VideoStar Connections (Atlanta), which provides business TV services.

Another sign of the success of business TV is the increasing number of business networks that offer programs on a fee-for-service basis. These networks are sponsored either by professional societies or by private companies that offer the service to specific industries. Among others, networks serving certified public accountants, lawyers, and healthcare professionals are currently available.

An example of such a network in the finance sector is the Private Satellite Network (PSN) in New York, which has established the Institutional Research Network. Public corporations can use IRN to broadcast their financial messages and stockholder reports to large institutional investors. The network also broadcasts investor-relations presentations, corpo-



Dan McConnell, shown at A. L. Williams's in-house TV production studio, says the company broadcasts about 40 hours of programming a month (the t-shirts on the seats are given to employees in the audience to identify them by group).

CHUCK ROGERS

rate conferences, and meetings of the New York Society of Securities Analysts. A popular aspect of this network is that it can remotely switch on videotape recorders at downlink sites, so if institutional in-

vestors cannot watch or participate in the broadcasts, they can view them later.

Most established networks develop their own programs, but others contract programming out to companies that spe-

cialize in this service. J. C. Penney Communications (New York) is one of the largest players in this market. Begun as an internal television network to speed communications between fashion buyers and Penney stores, the firm was spun off as a subsidiary in January 1986.

While J. C. Penney Communications produces a broad spectrum of corporate programs, other companies concentrate on niche markets. Business Management Uplink Service (BMUS) of Tempe, Ariz., specializes in computer industry programming. BMUS is a wholly owned subsidiary of MicroAge Computer Stores, which uses the service to broadcast programs similar to those of Computerland. "But we also provide satellite programs about computer technology and training to computer specialty stores and to other satellite networks," says vice-president and general manager Tim Furst.

Once sold on the virtues of a business TV network, companies need not even worry about the logistics of establishing and maintaining it—third-party network providers such as VideoStar Connections exist for that purpose. "Our fundamental business," says Green, "is network management. We're like Federal Express: we pick up programs and deliver them, but we don't do production."

Among its other operations, VideoStar runs a "Tele-Meeting Network" consisting of 200 downlinks at hotels (primarily Marriotts) for use by companies that want to broadcast special events; broadcasts can originate anywhere the customer desires. Hi-Net Communications (Memphis), a subsidiary of Holiday Corp., owner of Holiday Inns, provides a similar downlink network for 1000 hotels.

Most experts agree that the potential of business TV has only just begun to be tapped. Besides providing two-way audio/one-way video presentations, for example, the satellite networks can also transmit data, a capability that the A. L. Williams network will introduce to control laser printers in its branch offices. This feature will allow the company to distribute handouts to accompany live broadcasts. Programming is also likely to become an area of innovation as companies grow more familiar with the possibilities of the television medium. □

Sam Diamond, a freelance writer based in Ridge, Long Island, N.Y., specializes in business and technology subjects.

Hong Kong works.

\$1.2 billion in sales proves it.

Products made by American companies in Hong Kong have achieved over \$1.2 billion in sales. The fact is, manufacturing in Hong Kong is extremely profitable, whether you're considering a joint venture or a plant of your own. And getting started is easier than anywhere else on earth. There is minimal government interference in the private sector. Consistent economic policies of free enterprise and free trade. No exchange controls. And profits tax is only 18.5%. There's a skilled and eager work force, the world's third largest container terminal and the most sophisticated communications system in the region. In just three years, foreign industrial investment in Hong Kong has risen 63%. The reasons are obvious. Profit without penalty, success without tears. Find out more about how Hong Kong can work for your company.

Contact:
Mr. Robert Ashworth, Hong Kong
Government Industrial Promotion
Office, Dept. A,
180 Sutter Street,
San Francisco, CA94104, U.S.A.
Telephone no. (415) 956-4560
Fax no. 1-415-421-0646

Mr. Paulus Chan, Hong Kong
Government Industrial Promotion
Office, Dept. A,
Tower 56, 14/F.,
126 East 56th St.,
New York, NY 10022, U.S.A.
Telephone no. (212) 752-3650
Fax no. 1-212-308-7827

Hong Kong works

Hong Kong Government Industrial Promotion

Save up to \$48.

- ☐ **Save \$48:** 36 issues of High Technology for \$60.
That's \$48 off the newsstand price.
- ☐ **Save \$6:** 12 issues of High Technology for \$30.
That's \$6 off the newsstand price.

☐ Bill me. ☐ Payment enclosed.

ITEMS 1-8 MUST BE COMPLETED BEFORE
SUBSCRIPTION CAN BE ENTERED.

1. NAME _____

2. TITLE _____

3. COMPANY _____

4. ADDRESS _____

5. CITY/STATE/ZIP _____

Mail subscription to: ☐ Company ☐ Home

Home Address _____

City/State/Zip _____

Those not qualifying may pay more than the basic rate. Please allow 4-6 weeks for delivery of the first issue. One year subscription to Canada: \$30 (US). All other foreign: \$60 (US). Basic rate: 12 issues \$30.



6. INDICATE THE TYPE OF BUSINESS AT YOUR LOCATION. CIRCLE ONLY ONE.

Manufacturing
Major Product of
Company or Division:
A Chemicals or Allied Products
B Machinery
(Except Electrical)
C Electrical or
Electronic Equipment
D Computers/Peripherals
E Transportation Equipment
F Measuring/Controlling
Instruments
G Other: _____

H Government or Military
I Construction/Engineering
J Services
Please Note Type:
K Computer or Software
L Other: _____

M Communications
N Transportation
P Banking/Finance
Insurance
Q Other: _____

7. INDICATE YOUR LEVEL OF RESPONSIBILITY.

A Top Management (Owner, Chairman, President, Executive or Senior Vice President, Vice President)
B Senior Operations and Financial Management (Division Head, Department Head, Profit Center Manager, etc.)
C Professional/Technical Management and Staff (Group Leader, Project Manager or Equivalent)

8. FUNCTIONAL RESPONSIBILITY (CIRCLE ONE ONLY)

A Business/Financial/Administrative
B Design/Engineering
C Manufacturing/Production/Operations
D Systems Information (MIS/EDP/Communications)
E Systems Integration/Technical Support
F Research & Development
G Other: _____

4CCE6

Free information: A reader service.

Use this card for quick information about the products and services advertised in High Technology. To receive information circle the reader service number appearing on each ad. Be sure to answer all questions completely. This information will help manufacturers reply more specifically to your request.

NAME _____

TITLE _____ PHONE _____

COMPANY _____

ADDRESS _____

CITY/STATE/ZIP _____

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60

- ☐ 1. Corporate Management
☐ 2. Technical Management
☐ 3. R&D Management
☐ 4. Engineering
☐ 5. Other

Manufacturing:

- ☐ A. Electrical Equipment
☐ B. Professional/Scientific Instruments
☐ C. Transportation
☐ D. Machinery (except elec.)
☐ E. Chemicals
☐ F. Other

- ☐ A. Under 50
☐ B. 50-99
☐ C. 100-499
☐ D. 500-999
☐ E. 1000-2499
☐ F. 2500-4999
☐ G. 5000-9999
☐ H. 10,000 or over

- ☐ G. Financial
☐ H. Professional/Business
☐ I. Government
☐ J. Other

(check all that apply)

- ☐ 1. Recommend
☐ 2. Specify
☐ 3. Approve

This card expires July 1, 1987

regular courses and special programming at all company sites. There is no charge to the student. Corporate subscribers now include AT&T, DEC, GE, IBM, DuPont, Honeywell, and Kodak. Future broadcasts over the network will include guest lectures by industry scientists.

modulation (PCM). The PCM method used for telephone transmissions samples the analog signals 8000 times a second and encodes each sample into an 8-bit word. This level of PCM produces high-quality voice signals, but the technique requires a 64-kilobit-per-second transmission channel.

connected via a microwave radio link carrying voice in analog form. Several analog-to-digital conversions can cause noticeable deterioration in speech quality. Fortunately, this problem will gradually disappear as public networks convert to all-digital transmission. ☐ — Terry Feldt



NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

Business Reply Mail

*First Class Permit No. 68, Boulder, Colorado
Postage will be paid by:*

HIGH TECHNOLOGY

*P.O. Box 2808
Boulder, Colorado 80321-0001*



NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

Business Reply Mail

*First Class Permit No. 27, Woburn, Mass
Postage will be paid by:*

HIGH TECHNOLOGY

*Reader Service Department
P.O. Box 2183
Woburn, Massachusetts 01888*



180 Sutter Street,
San Francisco, CA94104, U.S.A.
Telephone no. (415) 956-4560
Fax no. 1-415-421-0646

126 East 56th St.,
New York, NY 10022, U.S.A.
Telephone no. (212) 752-3650
Fax no. 1-212-308-7827

Hong Kong works



Hong Kong Government
Industry Department

broadcasts. Programming is also likely to become an area of innovation as companies grow more familiar with the possibilities of the television medium. □

Sam Diamond, a freelance writer based in Ridge, Long Island, N.Y., specializes in business and technology subjects.

B8526

EARNING DEGREES VIA SATELLITE

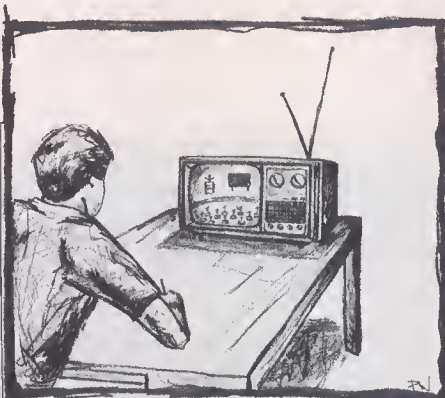
Several major universities and corporations have teamed up to create the nation's first "electronic university." Claiming neither a campus nor a regular faculty, the National Technological University (NTU), based in Fort Collins, Colo., broadcasts graduate-level courses via satellite to some 1200 working engineers and scientists at more than 80 corporate sites, and offers advanced degrees in various areas.

Continuing technical education is often cited as a must for maintaining America's international competitiveness. Yet more than 70% of today's new college graduates in engineering, lured by the brisk demand in industry and attractive starting salaries, choose to go to work rather than take on graduate studies; once on the job, most engineers do not return to school.

The private, nonprofit NTU, which has been operating since 1984, could help solve the problem by bringing "high-quality education to working engineers," says president Lionel V. Baldwin. NTU now awards master's degrees in computer science, electrical engineering, engineering management, and manufacturing systems; full accreditation by the North Central Association of Colleges and Schools is expected by August.

NTU classes are broadcast over two channels, 14-16 hours a day, on GTE Spacenet's G-Star I satellite; the 150 courses are drawn from 22 member universities, including Boston University, Georgia Tech, and Purdue. Seven of the universities can transmit (uplink) their courses directly to the satellite for nationwide broadcast; the other schools videotape their courses and mail them to one of the seven uplinks. About a third of the broadcasts are "live-interactive." The rest are delayed broadcasts of live classes.

Companies subscribe to the network for a one-time fee of \$65,000-\$260,000, depending on the number of employees; the fee provides permanent access to NTU's regular courses and special programming at all company sites. There is no charge to the student. Corporate subscribers now include AT&T, DEC, GE, IBM, DuPont, Honeywell, and Kodak. Future broadcasts over the network will include guest lectures by industry scientists.



Students can view the videotapes at their convenience, and can replay the tape as needed; if they still have questions, they can call the professor. Tests and homework are exchanged through the mail for grading and review.

"Without NTU, I could not have pursued a master's degree," says Michael Reiss, a computer analyst at NCR (Cambridge, Ohio). "The nearest school is an hour and a half away." Reiss received a master's in computer engineering at NTU's first commencement last November. With courses from Northeastern University (Boston) and the University of Minnesota (Minneapolis), Reiss earned his degree without leaving Cambridge or disrupting his work at NCR. □ —*Salvatore Salamone*

VOICE COMPRESSION FOR DIGITAL NETWORKS

The nation's telephone network, originally an analog system designed to carry only voice signals, is now shifting to a digital system suited to all types of traffic—from computer data to digitized video and voice. Digital networks promise improved efficiency and greater reliability, but digitized voice typically requires faster and more expensive communications channels than its analog counterpart. Consequently, telephone companies are turning to digital compression techniques that reduce bandwidth requirements without a significant loss of voice quality.

The digitizing of telephone voice signals has been done commercially since 1962, using a technique called pulse code modulation (PCM). The PCM method used for telephone transmissions samples the analog signals 8000 times a second and encodes each sample into an 8-bit word. This level of PCM produces high-quality voice signals, but the technique requires a 64-kilobit-per-second transmission channel.

However, a recent refinement called adaptive differential PCM (ADPCM) cuts the transmission rate in half by exploiting the predictable behavior of analog speech signals. Special algorithms use that predictability to reduce each 8-bit PCM word to a 4-bit ADPCM word, taking into account such factors as the prior sample value and the predicted value of the next sample. Although the technique doesn't allow digitized voice to travel over ordinary analog phone lines (which can handle just 9.6 kilobits per second), it does double the number of channels that can be carried on a high-capacity line.

ADPCM has been adopted for digital voice transmissions by the Consultative Committee on International Telegraphy and Telephony (CCITT), the international standards-making body for telephone communications; suppliers such as AT&T Network Systems and M/A-COM Telecommunications have already announced ADPCM products.

CCITT's adoption of the techniques resulted from its investigation of ADPCM's voice quality. Telephone users in seven countries listened to ADPCM speech in their native tongues and rated it in comparison with PCM speech. Henri G. Suyderhoud, a principle scientist at Comsat Laboratories (Clarksburg, Md.) who worked on the evaluation, reports that "ADPCM scored slightly below the standard PCM. But in terms of general performance, the difference would not be perceptible to the general public."

Many digital switches installed today can handle only conventional PCM signals, so they may have to be transcoded several times from ADPCM to PCM and back as they travel through the network. Fortunately, multiple transcodings result in only minor degradation of the voice quality, most of it due to rounding-off errors in the initial conversion of analog signals into the ADPCM format. Once digitized, subsequent errors can be detected and corrected by digital signal processing.

Significant degradation can creep in, however, when networks require intermediate analog transmission links—for example, if two digital fiber optic trunks are connected via a microwave radio link carrying voice in analog form. Several analog-to-digital conversions can cause noticeable deterioration in speech quality. Fortunately, this problem will gradually disappear as public networks convert to all-digital transmission. □ —*Terry Feldt*

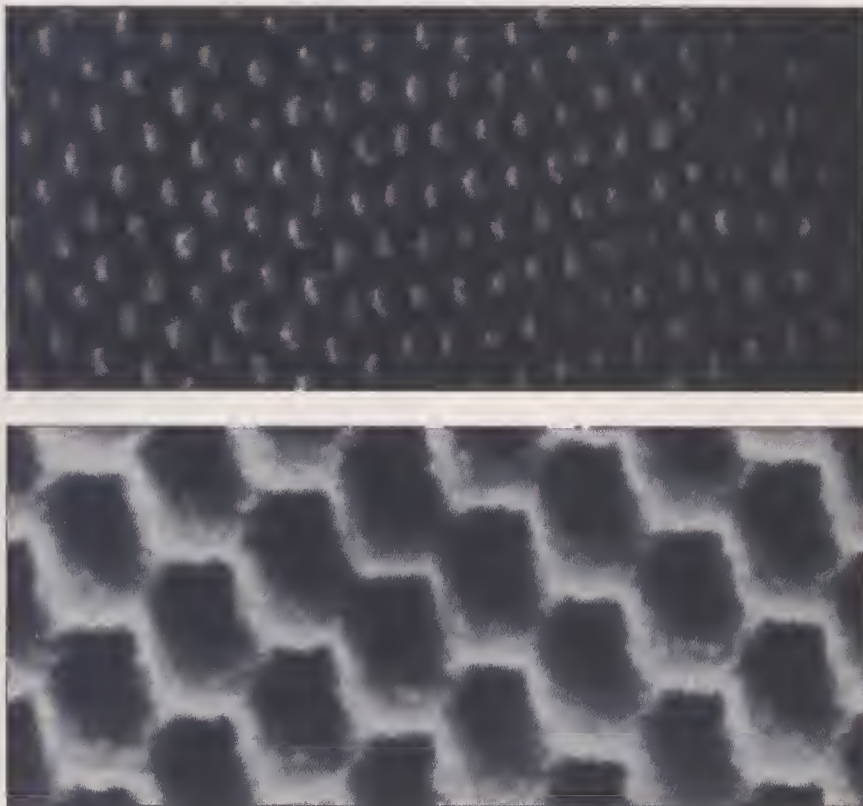
MOTH'S EYES INSPIRE ADVANCES IN OPTICAL DEVICES

Researchers at two British firms have copied the unusual eye structure of the common moth to produce new optical devices. The products are now limited to optical data-storage discs, but could later include instant, inexpensive medical diagnostic kits, map-projection systems for automobiles, and glare-free instruments and computer screens.

The technology evolved from observations that the moth's eye does not reflect light, a unique feature that seems to allow the insect to sit in open daylight without revealing itself to birds by glints of light from its large eyes. This protection is provided by a three-dimensional hexagonal grid—called a corneal nipple array—on the eye's surface that traps virtually all the light that hits it. That bit of esoterica is now being used by Plasmon Data Systems Ltd. in Melbourn, England, to produce "write once read many" (WORM) optical data storage discs (blank discs that users can fill with megabytes of their own data).

The discs consist of an inexpensive sub-micron film of platinum covered on both sides with clear plastic that has been embossed with a nonreflective three-dimensional grid. Data are recorded on the disc (as they are on any WORM disc) by laser-writing tiny dots to represent the 1's of binary code. The beam melts the plastic, destroying the grid and exposing a tiny area of bright platinum; these areas are read by scanning the disc with a low-power laser that reflects off the dots. Peter Helfet, Plasmon's managing director, explains that because of the very high contrast between the dots and the nonreflective grid (as high as with costlier production methods, he claims), data can be packed more densely than with other low-cost methods, as well as be read much more accurately.

The high contrast also results in a higher rate of usable discs per production run, says Helfet, since normal slight variations in the contrast—which would render many other discs unusable—are not critical. And because the plastic-molding technique (developed by PA Technology in



Close-up of moth's eye (top) shows nonreflective grid structure. Below, grid is molded on plastic to create high-contrast optical data-storage discs.

Cambridge, England) uses simple, readily available manufacturing equipment, he adds, production costs are expected to be up to 50% lower than with other commercial methods.

Plasmon has recently begun limited production of 5¼-inch discs in Britain, and plans a scale-up through 1988 to supply the European market. (The company has a marketing branch in San Jose, Cal., and plans to open a U.S. plant by mid-1988.) The company has also launched a joint venture with Japanese chemical maker Kuraray, which is scheduled to begin making discs by fall to supply the Pacific market and act as a second source for U.S. buyers.

Although Plasmon is concentrating on optical discs, PA Technology is looking into moth-eye technology for other applications—eliminating reflections from plastic automotive and airplane instrument covers, windshields, and computer screens, for example. In addition, grids etched into car windshields could display road maps projected from the dashboard

without blocking the driver's vision. The grid could be designed to reflect only lines of a specific wavelength; the rest of the image would be transmitted through the grid and would thus be invisible to the driver.

The company has also developed an instant blood-typing system made up of small plastic strips covered with moth-eye gratings that break light into its various wavelengths; the strips are then coated with proteins that react with type-specific blood chemicals. When blood is spread on the strip, the reaction changes the wavelength of the light that is transmitted through the grating, producing a different color for each blood type. The method thus provides a fast, simple, and inexpensive blood-typing test that could be performed in the doctor's office or under battlefield or emergency conditions, according to PA Technology's Donald Simon in Hightstown, N.J. The system is now in clinical trials, and commercialization is expected by early 1988. □

—G. Berton Latamore

Information sources for topics covered in our feature articles

ARTIFICIAL INTELLIGENCE, p. 16

Proceedings of the Second Annual Artificial Intelligence & Advanced Computer Technology Conference. Tower Conference Management Co., Wheaton, IL, 1986. AI applications ranging from medicine to office automation to image processing.

Artificial Intelligence Enters the Marketplace. Larry R. Harris & Dwight B. Davis. Bantam Books, New York, 1986. Describes the underlying technology of expert systems and natural-language processing.

Readings in Medical Artificial Intelligence: The First Decade. William J. Clancy & Edward H. Shortliffe, eds. Addison-Wesley Publishing Co., Reading, MA, 1984. Covers AI programming concepts.

Applied Artificial Intelligence Reporter (Intelligent Computer Systems Research Inst., Univ. of Miami). Monthly newsletter covering applications as well as industry conferences, companies, and products. \$98/yr.

"Artificial intelligence enters the mainstream." Dwight B. Davis. *High Technology*, July 1986. Examines how traditional computer vendors are moving to integrate AI technology with their existing products.

"Software tools speed expert system development." Paul Kinnucan. *High Technology*, March 1985.

Artificial Intelligence Markets (AIM Publications, Natick, MA). Monthly newsletter focuses on a major AI topic each issue. \$255/yr.

AI Trends (DM Data, Scottsdale, AZ). Monthly newsletter includes summary articles on AI markets and profiles of companies. \$295/yr.

CHEMICAL MAKERS GET IN SHAPE, p. 28

"Reshaping the chemical industries." Charles H. Kline, *Chemtech*, Aug. 1986. Describes some of the dramatic changes in the industry, with restructuring tips for chemical producers.

"Is Celanese playing only to Wall Street?" *Business Week*, April 28, 1986. How one company's strategies are seen by investors.

"The U.S. chemical industry: Restructuring for the future." A. Nicholas Filippello, *Business Economics*, Oct. 1985. Examines some of the forces impinging on chemical producers.

"World chemical outlook: Special report." *Chemical & Engineering News*, Dec. 15, 1986.

"Pinning down a global marketing strategy." *Chemical Week*, Oct. 1, 1986. How several U.S. companies are turning to new markets, at home and abroad, to perk up profitability.

PORTABLE COMPUTERS, p. 36

Companies

Colby Systems Corp., 2991 Alexis Dr., Palo Alto, CA 94303, (415) 941-9090.

Datavue, One Meca Way, Norcross, GA 30093, (404) 564-5555.

Dynamac Computer Products, 1536 Cole Boulevard, Building 4, Suite 252, Golden, CO

80401, (303) 233-7626.

Hewlett-Packard, 1000 NE Circle Blvd., Corvallis, OR 97330, (503) 757-2000.

Inteltec, P.O. Box 209, Fairfield, IA 52556, (515) 472-2000.

Manzana Microsystems, P.O. Box 2117, Goleta, CA 93118, (805) 968-1387.

NEC Home Electronics (U.S.A.), Computer Products Div., 1255 Michael Dr., Wood Dale, IL 60191-1094, (312) 860-9500.

Server Technology, 1095 E. Duane, Suite 103, Sunnyvale, CA 94086, (408) 738-8377.

Tandy Corp., 1700 One Tandy Center, Fort Worth, TX 78102, (817) 390-3300.

Toshiba America, 9740 Irvine Blvd., Irvine, CA 92718, (714) 380-3000.

Traveling Software, 19310 North Creek Pkwy., Bothell, WA 98011, (800) 343-8080.

Wang Laboratories, 1 Industrial Ave., Lowell, MA 01851, (617) 459-5000.

White Crane Systems, 6889 Peachtree Industrial Blvd., Suite 151, Norcross, GA 30092, (404) 454-7911.

Zenith Data Systems, 1661 Feehanville Dr., Mount Prospect, IL 60056, (312) 699-4800.

References

"Dawn of the portable computer." Cary Lu. *High Technology*, Sept. 1983. Detailed discussion of design issues.

"Displays." *IEEE Spectrum*, July 1985. Four ar-

ticles on display technologies, one concentrating on displays for laptops.

DIAMONDS FIND NEW SETTINGS, p. 44

Contacts

Australian Defense Science and Technology Org., Dept. of Defense, Russell Offices, Canberra 2600, Australia, tel. 62-65-9111. Site of some of the most advanced research.

Russell Messier, Assoc. Prof. of Engineering Science and Mechanics, Penn. State Univ., Univ. Park, PA 16802, (814) 865-3704. Heads consortium on diamond film (membership \$20,000/yr).

Dale G. Thompson, Battelle Memorial Inst., 505 King Ave., Columbus, OH 43201, (614) 424-4387. Multi-client program to follow developments in diamond and diamond-like coatings.

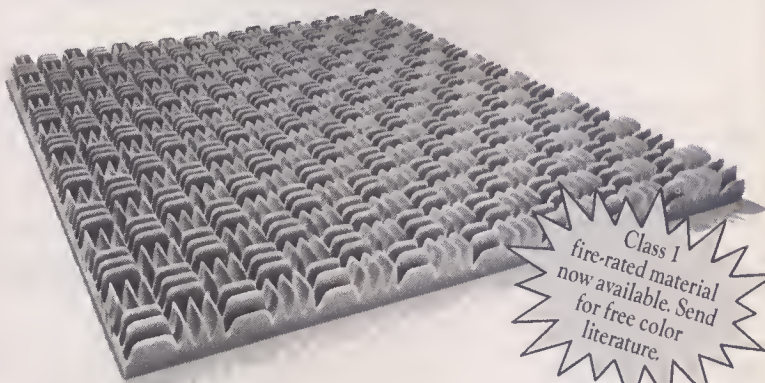
References

"From rocket to razor blade, diamond-coating era dawns." Malcolm W. Browne. *New York Times*, Sept. 14, 1986. A general account of projected payoffs from diamond films.

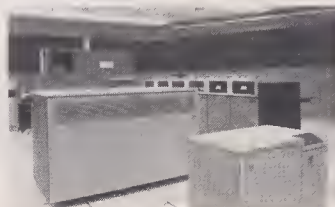
"Diamond films for chips and optical fibers." *Industrial Chemical News*, July 1986. Overview written for a technical audience.

"Is diamond the new wonder material?" Arthur L. Robinson. *Science*, Nov. 28, 1986. Review with emphasis on electronics applications.

HI-TECH NOISE KILLER



SONEX acoustic foam is deadly to annoying computer room noise. And it'll look great in your hi-tech environment. Simply hang sheets of this patented, professional foam to quiet the combined clatter of fans, motors and printers. Call or write for complete facts and a free brochure: 3800 Washington Ave. North, Minneapolis, MN 55412. (612) 521-3555.



illbruck

HIGH TECHNOLOGY CLASSIFIED

BUSINESS OPPORTUNITIES

Hi-Tech Manufacturing Opportunity

Sri Lanka born American hi-tech manager—17 yrs. U.S. experience—wants company to form subsidiary there. 90% leveraged financing for \$2-30M offered. English fluent labor 27¢/hour. 10 yr. tax holiday. (213) 544-0109.

START YOUR OWN BUSINESS. Catalog \$5.00 (Refundable). PSM, Box 327, Nyack, NY 10960.

MISCELLANEOUS

UNIQUE ARTWORK FOR THE FITNESS enthusiast. Send for free information. DS Expressions, P.O. Box 402-T, Neenah, WI 54956-0402.

VENTURE CAPITAL

Chicago Venture Capital Club

Opportunity for Chicago and Midwest entrepreneurs to present ideas to Midwest venture capital community. Entrepreneurs seeking funding for high growth ventures are invited to submit business plans for possible presentation at club meetings. Membership is comprised of prominent Chicago and Midwest venture capital firms. Typical minimum funding is \$300,000. Send business to Ms. Laura Girardi, c/o Arthur Young, 1 IBM Plaza, Chicago, IL. Next meeting—April. (312) 645-3394.

MANUFACTURING

LOCAL COMMUNITY SEEKING small manufacturing company interested in moving or expanding. Excellent workforce, reliable, loyal, trainable. Overnight markets. Truck, rail or air. Midwestern location. Respond to Box # 500.

ANTIQUES

ANTIQUE SCIENTIFIC & NAUTICAL instruments, microscopes, globes, telescopes, illustrated catalogs. Introductory subscription \$4. Historical Technology, Inc. 6S Mugford Street, Marblehead, MA 01945.

PATENTS & INVENTIONS

PATENT AND DEVELOP YOUR invention. Registered Patent Agent and Licensed Professional Engineer. Send for FREE PATENT INFORMATION. Every Inventor Should Have. Richard L. Miller, 12 Parkside Drive, Suite-T, Dix Hills, New York 11746. (516) 499-4343.

PATENTS & INVENTIONS

NEED A PATENT ATTORNEY? CALL or Write: John H. Crozier, Esq., 1934 Huntington Turnpike, Trumbull, CT 06611, (203) 375-9118. Free initial evaluation, followed by application and prosecution.

REGISTERED PATENT ATTORNEY will evaluate your invention and prepare and prosecute patent application if patentable invention is believed to exist. Edwin D. Schindler, Esq., 1523 East 4 Street, Brooklyn, NY 11230 or call (718) 336-9346.

INVENTORS! CAN YOU PATENT and profit from your idea? Call American Inventors Corporation for free information. Over a decade of service. 1-800-338-5656. In Massachusetts or Canada call (413) 568-3753.

LEARN HOW TO OFFER YOUR invention for sale or license. Free booklet outlines procedures, royalty rates, requirements. Kessler Sales Corporation, C-53, Fremont, Ohio 43420.

NEW IDEA? AMERICAN PATENT IN Washington, D.C. will assist you through RESEARCH and DEVELOPMENT! Free Kit—1-800-257-7880.

INVENTIONS, IDEAS, TECHNOLOGY wanted! Call free 1-800-528-6050. Canada, 1-800-528-6060. X831.

INVENTORS! CALL AIM—WE present ideas to manufacturers. For free information kit, 1-800-225-5800.

COMPUTER SUPPLIES

US\$8.00 INCLUDING DISK THOUSANDS name brand programs for Apple, IBM/PC. Details US\$1.00, RELIANT, P.O. Box 33610, Sheungwan HongKong.

BUSINESS SERVICES

MARKET YOUR PRODUCTS AND services overseas through advertising in foreign publications. Contact HR Advertising Agency, P.O. Box 9492, Wilmington, Delaware 19809. (302) 762-6919.

INCORPORATE WITHOUT LEGAL fees! Free booklet tells How, Includes Forms. Call Harvard Business Services Now: (800) 345-CORP.

CUSTOM EMBROIDERED CLOTHING. Your logo. Free set-up. 800-654-0777 or 615-968-7777.

BUSINESS SERVICES

MARKET RESEARCH AND STRATEGIC business planning for high technology products and processes. Ultra-Research, Inc., P.O. Box 307, Atwood, CA 92601 (714) 524-1150.

'USE AN AD AGENCY WHO UNDERSTANDS high tech.' Full service. Five branch offices. COLLE & MCVOY, Dick Moore (612) 851-2539.

PUBLICATIONS

The Maryland High-Tech Directory

puts you in touch with Maryland's rapidly growing high-tech community! This information-packed directory includes complete data, cross-referenced by SIC number, about more than 850 Maryland high-tech companies in the service and manufacturing sectors. Send a \$25 check to the Maryland Department of Economic and Community Development, Dept F-1, 45 Calvert Street, Annapolis, MD 21401, or call (301) 974-2041.

How to Publicize A Growing Company

Sherwood Ross,
P.R. Director, Inc. Magazine

50 page do-it-yourself action manual with sample releases for national and local TV, radio & press visibility. Send \$14.95 to Sherwood Ross, 2-13 Pheasant Hollow Dr. Plainsboro, NJ 08536, 609-275-0963

VIDEO

CABLE TV CONVERTERS. SCIENTIFIC Atlanta, Jerrold, Oak, Zenith, Hamlin. Many others. 'New' VIDEO HOPPER 'The Copy Killer'. Visa, M/C and AMEX accepted. Toll free 1-800-826-7623. B&B, Inc. 10517 Upton Circle, Bloomington, MN 55431.

'GRAND CANYON', 2-HOUR SPECTACULAR helicopter exploration video. Breathtaking music. Critically acclaimed. Details FREE. Beerger Productions, 3217-V25, Arville, Las Vegas, Nevada 89102. (702) 876-2328.

EDUCATION

UNIVERSITY DEGREES WITHOUT classes! Accredited Bachelor's, Master's, Doctorates. Free Revealing Information. Careers-HT04, Box 470886, Tulsa, OK 74147.

FREE COLLEGE TAPE EXTERNAL degree programs: Business Administration, Public Administration, LAW (Qualify Bar Admission). Fully Accredited, Financial Aid, (800) 847-0005, (314) 426-0653. LaSalle University, 3628 Saint Gregory, B52, Saint Louis, Missouri 63074.

EDUCATION

A UNIVERSITY DEGREE CAN UNLOCK your earning power. Complete your B.A., M.B.A., Ph.D., or J.D. Credit for Occup./Prof. experience. No classroom attendance required. Registered with California Committee of Bar Examiners. KENSINGTON UNIVERSITY, 330 N. Glendale Avenue, Glendale, CA 91206. In California 800-421-9115, X38. Other States, 800-423-2495, X38.

LEARN TO BE A TELEVISION STUDIO technician: after only fourteen months earn your degree and a great career in Video. Financial Aid and National Placement Assistance. VIDEO TECHNICAL INSTITUTE: Dallas (214) 263-2613 or Long Beach (213) 595-1660.

BACHELORS, MASTER'S, DOCTORATES. Guide to colleges offering non-residential degree programs through independent home study. Accredited, economical, accelerated programs. Credit given for prior accomplishments and work experiences. Free detailed brochure. Write: Dr. John Bear, P.O. Box 11447-HT, Marina Del Rey, CA 90295.

ALL REPLIES TO BOX NUMBERS

that appear without an address should be sent to:

HIGH TECHNOLOGY MAGAZINE
38 Commercial Wharf
Boston, MA 02110

**Put your ad before
the business executives keeping
abreast of changing
technologies and
their business
applications.**

Call or write today for more
information on High Technology
Classifieds

**Classified Advertising Dept.
38 Commercial Wharf
Boston, MA 02110-3883
617-227-4700**

ATHENS CORP.:

Cleaner chemicals for chip processing

During fabrication, traditional semiconductor wafers are repeatedly cleaned in piranha baths (hot, concentrated sulfuric acid combined with a strong chemical oxidant such as hydrogen peroxide). Manufacturers replace these chemicals every few hours to avoid contaminating the wafers, but this routine causes waste-disposal problems and recurrent production downtime. Athens has developed a reprocessing system called Piranha Piranha that recycles and repurifies the acids to their original strength and purity and provides a continuous flow of fresh chemicals. The Piranha Piranha system is currently in operation at Fairchild Semiconductor, and other chip makers plan to purchase it soon. In mid-1987, Athens plans to ship other products, such as a hydrofluoric-acid reprocessor for cleaning wafers and quartz diffusion tubes, and a new "no-moving-parts" wafer dryer. In addition to the semiconductor industry, the company is targeting the printed circuit board, medical, mining, and pharmaceutical markets.

Financing: \$6.9 million in venture capital from investors including Fairchild Semiconductor, Crosspoint Venture Partners, Columbine Venture Fund, Fairfield Venture Partners, Oxford Partners, Steuben Partners, and Grace Venture Partnership.

Management: R. Scot Clark (president and CEO) was VP of sales for Genus and process engineering manager at Texas Instruments. Joe Hoffman (VP of technology) was wafer fabrication manager for Mostek.

Location: 602 Airport Rd., Oceanside, CA 92054, (619) 757-4370.

Founded: October 1985.

QUADTREE:

Simulation models for microprocessors

Digital designers and test engineers can now use software simulation models to develop and debug microprocessor-based systems and single-board computers. Quadtree's simulation models—which run

on Sun Microsystems and Apollo workstations, using HHB Systems' CADAT and Silvar-Lisco HELIX logic simulators—are claimed to be the only ones available that perform all the functions of the actual devices they simulate. The company currently has certification agreements, which assure customers of the accuracy of the models, with Texas Instruments and Weitek Corp. for a series of complex processors. In some cases, certified models are ready before device samples are available from the IC manufacturer, thereby allow-



Hobbs (left) and Goldstein of Quadtree, whose software reportedly simulates all the functions of a chip.

ing digital engineers to incorporate the latest device designs into products sooner. Quadtree also offers simulation models of the complex Motorola MC68000 and MC68010, and Advanced Micro Devices AM2900 microprocessors. Besides IC manufacturers and CAE vendors, potential markets for Quadtree's simulation models include aerospace, computer, and telecommunications firms.

Financing: \$1.7 million in venture capital from Crosspoint Venture Partners and Venturetech Associates.

Management: Roger T. Hobbs (president and CEO) was VP of software products and services at Burroughs Corp. Co-founders William D. Billowitch (executive VP) and Matthew A. Goldstein (VP of engineering) were associate members of the technical staff of ITT's Avionics Division.

Location: 1170 Rte. 22 East, Bridgewater, NJ 08807, (201) 725-2272.

Founded: February 1984.

MYRIAD CONCEPTS:

Merging digital data and voice transmission

Conventional phone lines ordinarily carry only one voice or one low-speed data stream at a time. But Myriad Concepts has designed a digital local loop transmission system that can channel high-speed data and voice simultaneously over existing twisted-pair telephone wires. Myriad's proprietary DLS 5000 system uses a time-compression multiplexing technique to transmit either two voice channels, two data channels, or one of each at distances of up to eight miles and data speeds of 64 kilobits per second for each channel (three to six times faster than previously possible over copper telephone wire). The system consists of two units—one installed at the customer's location, and another established at the telephone company's central office or a private network switching center. Myriad Concepts divides its projected market into five segments: interexchange carriers (long-distance telephone compa-

nies), private network companies, Centrex enhancement providers (telephone switching services that provide PBX features), Digital Data Service providers, and the Integrated Services Digital Network. Michigan Bell Telephone has purchased 16 of Myriad's DLS 5000 systems.

Financing: \$70,000 in seed capital from Advanced Technology Investments. \$1.3 million from a February 1987 public offering of 1.6 million common shares on the Vancouver Stock Exchange.

Management: Charles R. Boggs (president and CEO) was senior VP of Futuretek Communications. Co-founders Michael Sheppard (VP of engineering) and Allan L. Blevins (executive VP and COO) are co-holders of the company's DLS 5000 (digital subscriber loop) patent.

Location: 58 Corning Ave., Suite 58, Milpitas, CA 95035, (408) 943-0377.

Founded: August 1983.

—Margaret Woisard

MACHINE VISION BROADENS ITS HORIZONS

The market for machine vision systems was stimulated largely by General Motors' purchase of equity positions in five small vision companies. Now these systems are finding increasing application in other manufacturing sectors as the technology improves and as automotive firms cut back their spending. The systems—which convert optical images into electronic signals that are processed into recognizable patterns—enable robots and other machines to inspect products, measure distances, guide parts, and sort packages, among other tasks. The annual world market for vision devices is currently about \$100 million, and should exceed \$500 million within five years, according to Piper, Jaffray & Hopwood (Minneapolis).

Consumer, aerospace, and electronics companies are among the recent users of vision products. For example, systems are being developed by Federal Express to read mailing labels in order to sort packages automatically, by the Navy to examine aircraft rivets, and by Zenith to inspect printed circuit boards crammed with surface-mount devices.

With few exceptions, machine vision suppliers have not performed well from an investment standpoint. The technology turned out to be more difficult to commercialize than had been anticipated; customized applications were usually less profitable than standardized products, and the reliability of early systems was poor. However, some vendors—in particular, International Robomation/Intelligence (Carlsbad, Cal.) and Medar (Farmington Hills, Mich.)—have proven attractive on the basis of their distinctive technologies, their focus on standard products,

by Roger W. Redmond



In Robomation's vision system for inspecting printed circuit boards and surface-mount devices, a moving strobe light, mounted with the camera on a robot arm, prevents shadows that would otherwise make accurate inspection impossible.

and their potential for growth.

INTERNATIONAL ROBOMATION/INTELLIGENCE (OTC: IRIN) made a strategic decision early in its evolution not to sell directly to the automotive sector because of the potential danger of relying for revenues on a small group of customers. Instead, it produced vision systems that could perform sophisticated, interpretive inspections through the use of artificial intelligence techniques, and these products have found widespread application in the fast-growing aerospace and electronics markets. For example, Robomation is aggressively pursuing the surface-mount device sector with its Autoinspector Workcell series, which includes inspection stations, rework stations, and automated handling devices. Robomation has also increased

sales to large, potentially repeat-order customers such as IBM, AT&T, Federal Express, and Digital Equipment.

In fiscal 1986, the company's revenues were \$10.5 million, with profits of \$536,000 and earnings of 10¢ per share. These figures should climb in 1987 to an estimated \$13 million in revenues, \$1.4 million in profits, and 26¢ earnings per share.

Over the past few years, MEDAR (OTC: MDXR), an established producer of microprocessor-based industrial controls used in resistance welding, has developed a machine vision business that should contribute \$8 million, or 27%, of the company's revenues this year. Medar's vision product line is distinguished by the variety of input sensors that it offers, ranging from standard video cameras to scanning lasers, all of which contain chips to preprocess images at the sensor level before being transferred to the host computer. Medar's products are typically used in the automotive industry, where they detect variations in metal thickness and locate features on work

in progress, among other tasks. This information is then used by the system to prevent the production of defective parts. Medar is one of the few vendors that have been successful in the automotive sector, but the firm is planning to enter the aerospace and electronics markets as well.

Estimated revenues in this fiscal year (ending Dec. 31, 1987) should be \$30 million, with 30¢ earnings per share based on profits of \$1.9 million. Last year (ended March 31, 1986), Medar's revenues were \$10.9 million, but the company sustained losses of \$1.4 million (28¢ per share) due to order delays, nonrecurring acquisition, and consolidation expenses. □

Roger W. Redmond is a vice-president of Piper, Jaffray & Hopwood (Minneapolis).

WE'RE RIGHT NEXT DOOR!



Nova Scotia is next door to New England. Why don't you come and see for yourself that Nova Scotia is a good place to live, work and invest. Pratt & Whitney, Michelin and Magnus Aerospace did.

"There were several reasons why Pratt & Whitney located its new plant in Nova Scotia. First and foremost, was the availability in Nova Scotia of a large pool of manpower that could be trained easily to work in our facility and also, a very enthusiastic response from the Government of Nova Scotia to work with us to develop a very large training program to make it happen."

Gilles Ouimet, Senior Vice President-Operations, Pratt & Whitney Canada Incorporated

"Michelin has been located in Nova Scotia for 15 years. We have found the work force as equally productive as our best plants in Europe and the quality of workmanship second to none. Our progress has been as a result of people, our most valuable asset, and that is why Nova Scotia is the right place for Michelin to be."

Ronald C. Musgnug, Vice President, General Manager, Michelin Tires (Canada) Limited

"Our engineers have told us that the quality of the work is visibly superior to the work they usually see in other parts of the country. The skills possessed by many of the local people are simply outstanding; there are jewels on the rock of Cape Breton; they don't have to take a back seat to anybody on quality."

Jean Carr was project manager for the installation of the supercomputer in Sydney for Magnus Aerospace Manufacturing Corporation.

For more information on:
Industrial Regional Development Program
Investment Tax Credit
Research and Development Tax Credit
and many other programs.

Contact:
Nova Scotia Department of Development
World Trade and Convention Centre
1800 Argyle Street, P.O. Box 519
Halifax, Nova Scotia, B3J 2R7
Telephone (902) 424-5320
Telex 019 22548

Nova Scotia



**Department of
Development**

Hon. Roland J. Thornhill, Minister
Circle No. 25 on Reader Service Card.

BREAKTHROUGH: QUICK COOL ALLOYS SO THEY CAN TAKE THE HEAT.

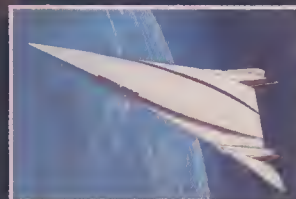
Build a plane that can fly from the U.S. to the Orient between lunch and tea? It can be done. But to build it, new lightweight materials are needed that can survive the heat of hypersonic speeds.

Our solution: A metallurgical recipe using molten titanium alloy and a special process in which the hot liquid metal is solidified into powder by extremely rapid cooling. After the powder is processed into a solid and worked into sheets, designers have a practical material for helping get hypersonic flight off the ground.

We're creating breakthroughs that make a difference in the way things work and the way people live.

We're McDonnell Douglas.

*For more information, write:
Orient Express, McDonnell Douglas,
Box 14526, St. Louis, MO 63178.*



MCDONNELL DOUGLAS

SPACECRAFT & MISSILES MILITARY & COMMERCIAL AIRCRAFT HEALTHCARE SYSTEMS INFORMATION SYSTEMS HELICOPTERS FINANCING